VISVESVARAYA TECHNOLOGICAL UNIVERSITY

Jnana Sangama, BELAGAVI

"POWER GENERATION USING HYBRID FORCE DRIVEN VERTICAL AXIS WIND TURBINE"

Project report submitted in partial fulfillment of the requirements for the award of

BACHELOR OF ENGINEERING
In
ELECTRICAL & ELECTRONICS ENGINEERING

Submitted by

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CERTIFICATE

Certified that the Project Work entitled "**POWER GENERATION USING HYBRID FORCE DRIVEN VERTICAL AXIS WIND TURBINE**" is a bonafide work carried out by **Ms. Ananya Shekar** (1DT20EE003), **Mr. Samar Raj Singh**(1DT20EE022), **Ms. Vaishnavi Patil** (1DT20EE032) and **Mr. Shripad Ukkali** (1DT21EE415) in partial fulfillment for the award of Bachelor of Engineering in **Electrical & Electronics** Engineering of the Visvesvaraya Technological University, Belagavi during the year 2023-2024. It is certified that all the corrections/suggestions indicated for internal assessment have been incorporated in the report deposited in the departmental library. The Project Report has been approved as it satisfies the academic requirements in respect of Project Work prescribed for the said degree.

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DECLARATION

We, the undersigned solemnly declare that the Project work report entitled, **“POWER GENERATION USING HYBRID FORCE DRIVEN VERTICAL AXIS WIND TURBINE”** is based on our work carried out during the course of our study under the supervision of Prof. Govindappa. R, Associate Professor, Department of Electrical and Electronics, Dayananda Sagar Academy of Technology and Management. We assert that the statements made and conclusions drawn are an outcome of the Project work. We further declare that to the best of my knowledge and belief that the Project work report does not contain any part of any work which has been submitted for the award of any other degree in this University or any other University

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ABSTRACT

In response to the rising need for renewable energy sources and traditional wind turbines' limitations in absorbing all available wind power, this study offers a new design for vertical axis wind turbines (VAWTs) that includes a generator and a booster motor. This integrated system tackles the issue of intermittent wind patterns by allowing continuous power generation while using kinetic energy stored in the turbine's blades during periods of low or no wind. The research combines information from mechanical, electrical, and sustainable energy fields, with an emphasis on improving performance, efficiency, and environmental effect. This study describes the theoretical background, design strategy, and technical specifications of the system, as well as its potential societal advantages and real-world applications. Hence, we hope that by publishing their findings, they can help to increase scientific understanding and drive future advances in renewable energy systems.

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CHAPTER 1

INTRODUCTION

With the increasing demand for the need of utilization of renewable sources of energy in order to overcome the shortcomings of the conventional sources of energy, there is high demand for the growth of Solar and Wind energy and yet many industry experts have not been able to consume the freely available sources in the environment. Focusing on the wind power generation in particular, over the years wind mill operators and technical experts have failed to achieve have failed to utilize the wind power which is available abundantly to its ultimate efficiency.

The pursuit of sustainable energy sources has prompted us to investigate the possibilities of vertical axis wind turbines (VAWTs) as a possible source of clean power generation. However, the intermittent nature of wind patterns poses a severe barrier to the steady generation of electricity from these turbines. In answer to this issue, our research aims to pioneer a system that incorporates a generator and a booster motor into the vertical axis wind turbine frame. This report recounts our innovation journey, from idea to execution, as we attempt to realize the full potential of this innovative technology.

At the heart of our idea is the integration of a generator and a booster motor with a vertical axis wind turbine, transforming it into a self-sustaining power generating system. Unlike traditional turbines, which rely entirely on wind currents to rotate, our integrated technology allows for continuous operation even in the absence of wind. We developed a method that provides a steady power production by exploiting the kinetic energy stored in the revolving blades, bypassing the constraints of typical VAWTs.

Our research brings together multidisciplinary knowledge from mechanical engineering, electrical engineering, and sustainable energy technology. We worked hard to improve our integrated system's performance and efficiency through diligent design iterations and rigorous testing processes. Furthermore, our attention extends beyond functionality; we are devoted to assessing our solution's environmental effect, economic feasibility, and scalability in order to promote wider adoption in real-world applications.

This study contains a complete overview of our revolutionary system's theoretical foundations, design techniques, and technical specifications. Furthermore, we explore the practical consequences and possible social advantages of incorporating hybrid-powered technology into vertical axis wind turbines. We hope that by sharing our study findings and empirical data, we may not only enhance scientific understanding but also inspire future renewable energy developments.

As stewards of the earth, it is our responsibility to investigate sustainable alternatives that alleviate the negative impacts of fossil fuel reliance. We are taking a huge step toward constructing a more resilient and sustainable future by accepting the challenge of harvesting wind power in novel ways.

CHAPTER 2

LITERATURE SURVEY

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 vertical axis wind turbine (VAWT) has gained considerable traction in recent years. Its quiet operation, simplified maintenance requirements, and attractive cost point compared to traditional turbines have all contributed to its growing popularity. These advantages make the Darrius VAWT an increasingly attractive option for wind energy generation [2].

A preliminary investigation was carried out to determine how the quantity of blades affects the efficiency of cross-flow wind turbines, a kind of vertical axis wind turbine. With three different blade configurations, the 0.4 x 0.4 m^2 turbine was tested experimentally. At low wind speeds of 2-3 m/s, the turbines were tested. Excellent performance of 16 blades was demonstrated by the findings. It was determined by them that the coefficient of performance (Cp) for a given number of blades in a cross-flow wind turbine may be raised by adding more blades to the device [3].

The impact of blade count on propeller hydrokinetic turbine designs was studied. In a particular low-rotational-speed working situation, the Cp of runners with two, three, and four blades is investigated using wind tunnel tests and simulations using blade element momentum theory. When compared to runners with more blades, the results indicated that runners with two and three blades performed less well. [4].

It demonstrated the fundamental principles, characteristics, and laws of permanent magnets. A few essential characteristics of Samarium Cobalt and Neodymium Iron Boron magnets, which are strongly advised for usage in electromagnetic engines, were examined. The engine's use of the crankshaft to convert electromagnetic energy to mechanical energy is efficient. He came to the conclusion that power generation solely uses the repulsive force between the magnet and electromagnet based on his manufactured prototype. The relay is controlled by the timer, which is used to accelerate. At 229 rpm and 1.2A of input current, the maximum efficiency was attained (21.22%) [5].

A novel concept for automobile engines proposes replacing traditional combustion engines with multi-cylinder electromagnetic engines. Each cylinder would house a piston and utilize samarium cobalt magnets positioned at a right angle to it. These magnets' high strength and heat tolerance are crucial for generating powerful electromagnetic forces that drive the pistons back and forth, potentially creating a cleaner and more efficient alternative to gasoline or diesel engines [6].

Implements a system that simulates the production curve of a wind turbine using an asynchronous machine (ASM) and a DC generator. With the use of a variable frequency motor, the ASM simulates wind conditions and produces voltages according to a production curve that is mimicked. The voltage of the DC generator is adjusted by a DC/DC power converter and then controlled to a steady 48Vdc bus. Additionally, models for DC generators and DC/DC power converters are included in the article [7].

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 [8].

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 [9].

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 [10].

This paper discusses various aspects of BLDC motor control. 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 sensor less 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 [11].

Utilizing wind power, a 12V-34V DC generator capable of 2400 RPM may transform mechanical energy into electrical energy. A charge controller receives the generator output and controls the charging process to prevent overload, overcharging, and overvoltage. This safeguard keeps deep discharge from happening while ensuring battery longevity and performance. Rechargeable batteries are used as an energy storage system when they are charged by the charge controller. Through the use of blades, the Vertical Axis Windmill transforms wind energy into kinetic energy, which then powers a 12-volt battery. The step-up transformer increases the voltage needed to operate the gadget as soon as the battery is turned on, and the inverter converts DC to AC [12].

The paper investigates a brushless DC (BLDC) motor control scheme using rotor position sensing. 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. [13].

Gives a summary of wind turbine generators that create a grid and talks about how various grid forming categories are being used. The grid-forming wind turbine generators' performance is greatly affected by the DC-link voltage.

Nevertheless, it is disregarded in the grid-forming controls that are currently in use. In the process of designing grid-forming wind turbine generators, this matter merits consideration [14].

The paper investigates H-Darrius wind turbines, focusing 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 [15].

Gap Analysis: This innovative vertical axis wind turbine tackles the challenge of inconsistent wind speeds, a major hurdle for traditional wind turbines. It boasts a unique combination of a DC generator and a booster motor working in tandem. At high wind speeds, both components transform into generators, maximizing power output. The booster motor essentially acts as a secondary generator, capturing additional energy alongside the main DC generator.

However, when wind speeds dip, the system adapts cleverly. The DC generator continues its primary function, while the booster motor takes on a supportive role. It helps maintain the turbine's rotation and contributes a lower amount of power generation until wind speeds pick up again. This ingenious design ensures the turbine continues to generate electricity even during periods of weaker winds, unlike conventional turbines that grind to a halt

CHAPTER 3

PROBLEM FORMULATION AND METHODOLOGY

3.1 Objective

1) The main aim of our project is to improve the present efficiency of the Wind Turbine through Hybrid Forces.
2) This Intricate effort is aimed at producing Electricity from the kinetic energy produced by the wind.

3.2 Problem Statement

1) Conventional wind turbines have a significant drawback that is they cannot generate electricity when wind speeds are low or non-existent.
2) This limitation leads to intermittent power generation, hindering the reliability of wind energy as a renewable source.
3) Our project aims to overcome this challenge by proposing a novel wind turbine design that leverages both wind and stored kinetic energy for continuous and improved electricity production.

3.3 Methodology

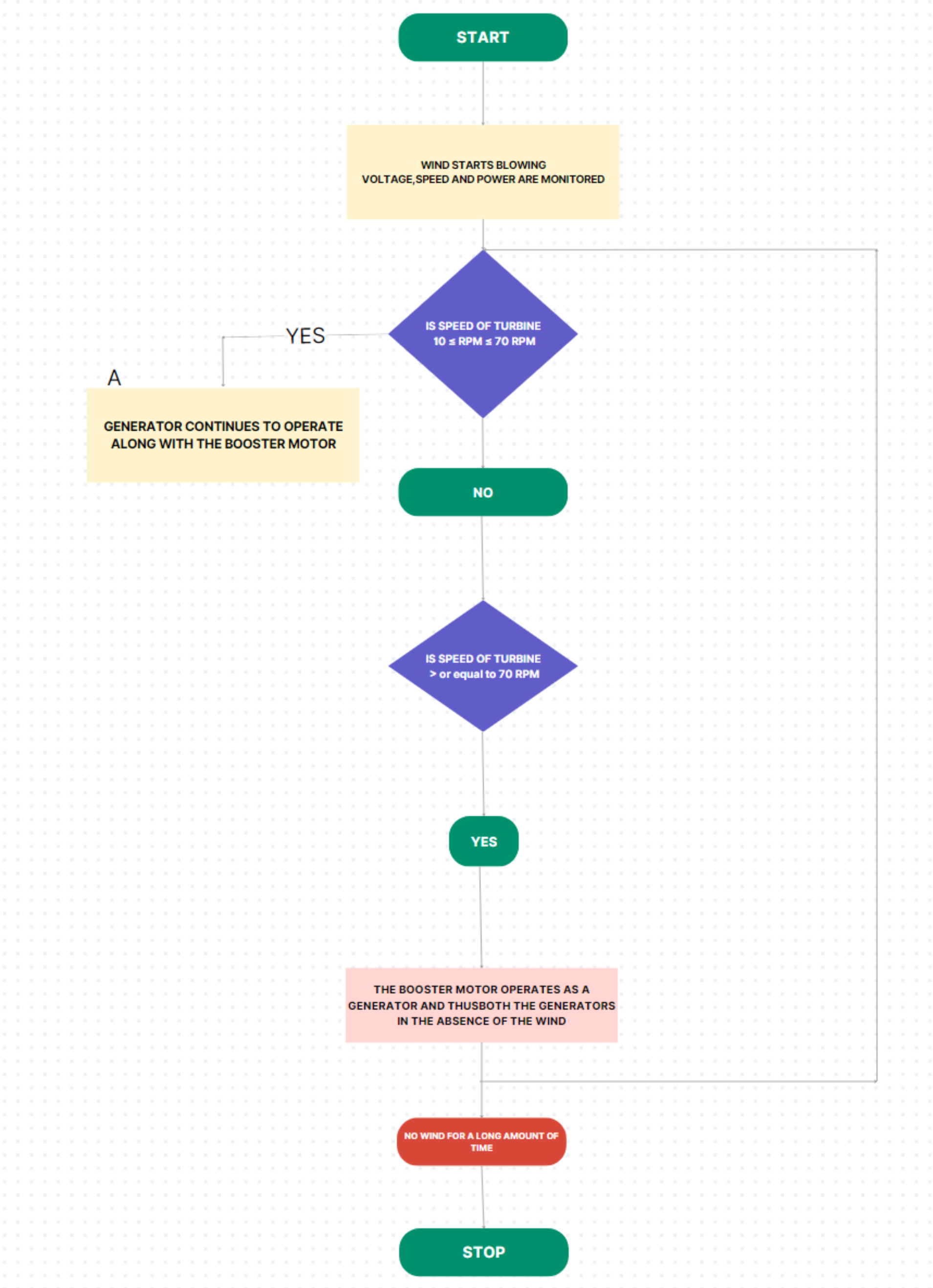

Fig 3.1 Flowchart of the Model

This approach tackles the intermittent nature of wind, a major hurdle in wind power generation. The key innovation lies in integrating a booster motor with a traditional DC generator within the Vertical Axis Wind Turbine (VAWT). This creates a two-stage system that optimizes power generation across varying wind speeds.

During Low Wind Speed (10-70 RPM)

- When wind speeds fall within the range of 10 to 70 RPM, the wind's force alone might not be sufficient to generate enough power to spin the turbine efficiently. In this scenario, the booster motor comes into play. It utilizes an external power source (potentially the grid or battery storage) to kick-start the VAWT and keep it running.
- Simultaneously, the DC generator starts functioning as well. However, at low wind speeds, the wind's contribution to generating electricity might be minimal.

During High Wind Speed (Above 70 RPM):

- As wind speeds rise above 70 RPM, the wind's energy becomes significant enough to efficiently spin the turbine. At this point, the booster motor's role transitions. It ceases to draw power from the external source and instead acts as an additional generator. This means both the DC generator and the booster motor (now functioning as a generator) work in tandem to produce ectricity. The combined output from both generators translates to increased overall power generation at higher wind speeds.

By incorporating the booster motor, the VAWT can potentially keep running even during low wind periods, eliminating downtime and ensuring a more consistent flow of electricity. The system automatically adjusts its operation based on wind speed. At lower speeds, the booster motor provides a kick-start, while at higher speeds, it joins forces with the DC generator to maximize power output. This approach allows VAWTs to potentially be utilized in areas with unpredictable or low average wind speeds, expanding the reach of wind energy generation.

CHAPTER 4

LIST OF COMPONENTS

4.1 HARDWARE IMPLEMENTATION

1) Arduino Nano

2)16*2 LCD Display

3) H-Rotor Wind Turbine

4) Dynamo/Generator DC Brushless Motor

5) BLDC Motor

6) BLDC ESC Electronic Speed Controller

7)Li-Polymer Battery

8)Hall Sensor

9)100 Ω Resistors

10)PCB Board

11) DC Bulb

12)Stand Alone 56 Teeth Gear

13) Stand Alone 14 Teeth Gear

14) 100µ Capacitor

15) 20µ Capacitor

16) Relay-Sugar Cube

4.2 SPECIFICATIONS OF THE COMPONENTS

Component specifications are a system's engineering blueprint, meticulously outlining each part's function (for example, pistons converting fuel to force), performance (in horsepower or watts), physical size and materials (essential for stress resistance), electrical properties (voltage and current limitations), and even environmental tolerance (ensuring operation in extreme temperatures or wet conditions). These thorough specifications ensure that all of the piece’s function together smoothly to meet the system's objectives.

4.2.1 Arduino Nano

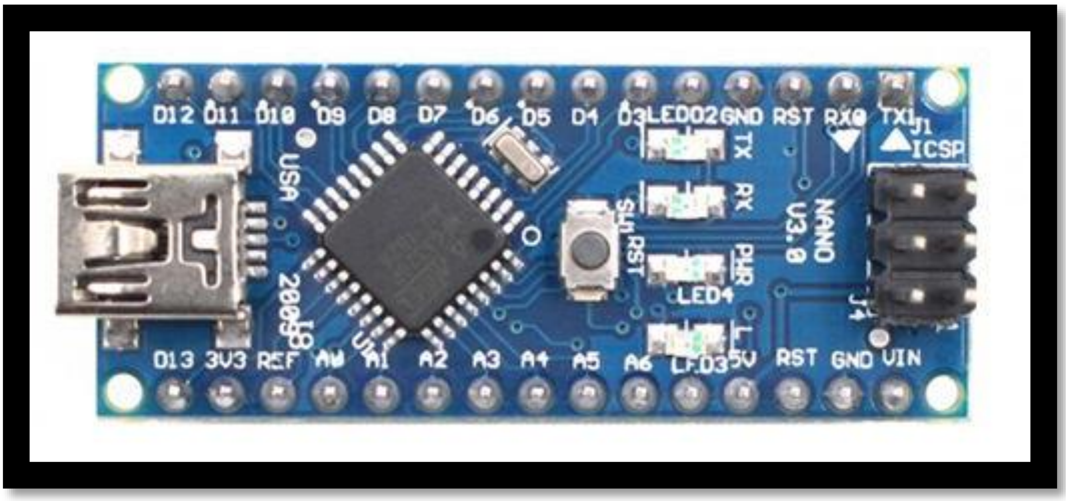

Fig 4.2.1

The Arduino Nano is a compact yet powerful microcontroller board based on the ATmega328P chip. It's similar to the Arduino Uno but smaller in size, making it ideal for projects where space is limited. Despite its small form factor, it retains many of the Uno's features, including 14 digital input/output pins, 6 analog inputs, and a USB interface for programming and communication. Its versatility and affordability make it popular among hobbyists, students, and professionals alike for a wide range of applications, from robotics and automation to wearable tech and IoT devices.

The Arduino Nano boasts several advantages that make it a favorite among electronics enthusiasts and professionals alike. Its compact size is a standout feature, allowing it to fit into projects where space is limited without sacrificing functionality.

4.2.2 16*2 LCD Display

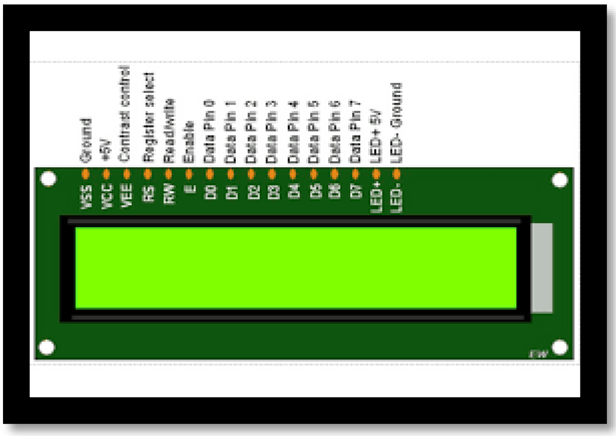

Fig 4.2.2

A 16x2 LCD (Liquid Crystal Display) is a common type of alphanumeric display used in various electronic devices. It consists of 16 columns and 2 rows of characters, allowing for the display of up to 32 characters at a time. These displays are popular in embedded systems and DIY projects for showing information such as text messages, sensor readings, or system status. They typically utilize a simple interface, making them easy to integrate with microcontrollers or other control circuits.

The 16x2 LCD display offers several advantages in various applications. Firstly, its compact size makes it ideal for devices where space is limited. Additionally, it provides a clear and easily readable display of alphanumeric characters, making it suitable for presenting text-based information. Its low power consumption is another key advantage, ensuring efficient operation in battery-powered devices.

Furthermore, the simplicity of its interface facilitates straightforward integration with microcontrollers and other control circuits, simplifying the development process for electronic projects. Overall, the 16x2 LCD display offers a cost-effective, versatile, and user-friendly solution for displaying information in a wide range of applications.

4.2.3 H-Rotor Wind Turbine

Fig 4.2.3

The H-rotor wind turbine is a type of vertical axis wind turbine characterized by its H-shaped rotor configuration. Unlike traditional horizontal axis turbines, which have blades that rotate around a horizontal axis, the H-rotor turbine's blades rotate around a vertical axis. This design offers several advantages, including the ability to capture wind from any direction without the need for a yaw mechanism, making it suitable for turbulent wind conditions. Additionally, H-rotor turbines are generally quieter and easier to maintain than their horizontal axis counterparts. However, they may have lower efficiency and require more complex engineering due to the asymmetrical loading on the rotor. Despite these challenges, H-rotor wind turbines continue to be explored and developed as a promising alternative in the renewable energy landscape.

The H-rotor wind turbine presents several advantages in the realm of renewable energy generation. Its distinctive H-shaped rotor configuration allows it to capture wind from any direction without needing a yaw mechanism, making it particularly suitable for turbulent wind conditions. This versatility enhances its efficiency in diverse environments. Furthermore, H-rotor turbines tend to be quieter and easier to maintain compared to traditional horizontal axis turbines, as they have fewer moving parts and simplified mechanical systems.

4.2.4 Three – phase miniature double bearing, Inner Rotor DC Brushless Motor High Voltage Dynamo

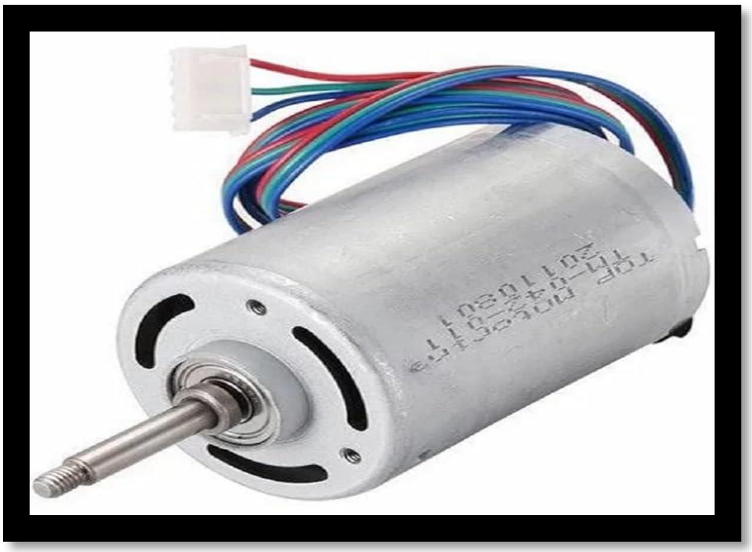

Fig 4.2.4

This is a miniature, three-phase brushless DC motor that can also function as a high voltage dynamo. The brushless design means it uses electronic controls instead of brushes, leading to smoother operation, less wear, and a longer lifespan. Its miniature size makes it ideal for space-constrained projects.

As a motor, it utilizes electromagnetism to spin. When spun in the opposite direction, it acts as a generator, producing high voltage DC electricity. This makes it a versatile component suitable for applications needing either a compact motor or a generator that harvests power from rotation.

4.2.5 A2212 1400KV BLDC Brushless Motor

Fig 4.2.5

The A2212 1400KV BLDC Brushless Motor is a workhorse for hobbyist drones and multi rotors. Its small size, likely around 22mm in diameter and 12mm long, makes it perfect for fitting into compact frames. The 1400KV rating indicates a good balance between speed and torque. With a higher KV rating, the motor will spin faster at a given voltage, but generate less turning force. This 1400KV motor offers a good compromise for general drone flight.

Another key advantage of this motor is its brushless design (BLDC). Unlike brushed DC motors, it uses electronic controls instead of brushes to create a rotating magnetic field. This translates to several benefits: smoother operation for a more stable flight, higher efficiency leading to longer flight times, and less maintenance due to the absence of wearing brushes. Overall, the A2212 1400KV BLDC motor offers a reliable and efficient option for powering your drone projects.

4.2.6 SimonK Red 30A BLDC ESC Electronic Speed Controller with Connectors

Fig 4.2.6

Simonk 30A BLDC ESC Electronic Speed Controller is specifically made for quadcopters and multi-rotors. Which provides faster and better motor speed control giving better flight performance compared to other available ESCs.

Simonk 30A BLDC ESC Electronic Speed Controller can drive motors which consume current up to 30A. It works on 2S-3S LiPo batteries. This electronic speed controller offers a battery eliminator circuit (BEC) that provides 5V and 2A to the receiver so we don’t need extra receiver battery.

This version of the ESC also includes backwards-polarity protection and protection on the 5V receiver line, this means that if you accidentally attach a battery backward it won’t destroy your motor controller and other BECs won’t affect the ESC.

4.2.7 11.1V 2200mAh 30C 3S Lithium Polymer Battery Pack

Fig 4.2.7

Orange 2200mAh 2S 30C/60C Lithium polymer battery Pack (LiPo) batteries are equipped with heavy-duty discharge leads to minimize resistance and sustain high current loads. Orange batteries stand up to the punishing extremes of aerobatic flight and RC vehicles. Each pack is equipped with gold plated connectors and JST-XH style balance connectors. All Orange Lithium Polymer batteries packs are assembled using IR matched cells.

4.2.8 Hall Sensor

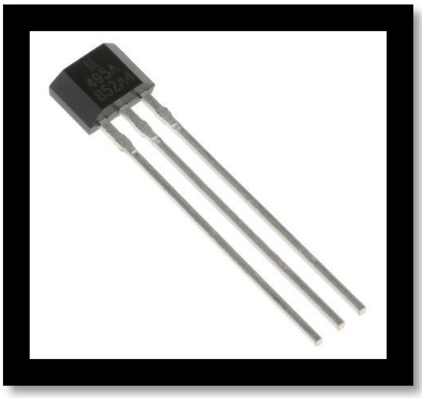

Fig 4.2.8

Hall sensors are compact, solid-state devices that sense the presence and strength of magnetic fields. Unlike traditional magnetic switches that require physical contact, hall sensors operate based on the Hall effect. This principle states that when a conductor experiences a magnetic field perpendicular to its current flow, a voltage difference is induced across the conductor's width.

4.2.9 100 Ω Resistors

Fig 4.2.9

The 100Ω resistor is a tiny but essential building block in electronics. It's a passive component that acts like a roadblock for electricity in a circuit. The higher its resistance (in ohms), the less current it allows to flow. This controlled restriction helps regulate current flow and protects sensitive components from damage.

100Ω resistors have a wide range of applications. Their small size and common value make them a must-have for any electronics project.

4.2.10 PCB Board

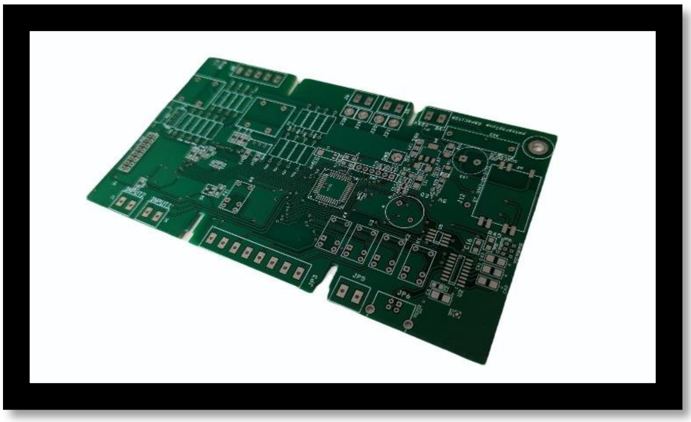

Fig 4.2.10

A printed circuit board, or PC board, or PCB, is a non-conductive material with conductive lines printed or etched. Electronic components are mounted on the board and the traces connect the components together to form a working circuit or assembly.

A PC board can have conductors on one side or two sides and can be multi-layer — a sandwich with many layers of conductors, each separated by insulating layers.

The most common circuit boards are made of plastic or glass-fibre and resin composites and use copper traces, but a wide variety of other materials may be used. Most PCBs are flat and rigid but flexible substrates can allow boards to fit in convoluted spaces.

4.2.11 DC 12V 2.4W Coin COB High Brightness Waterproof Injection Module with Clear Lens

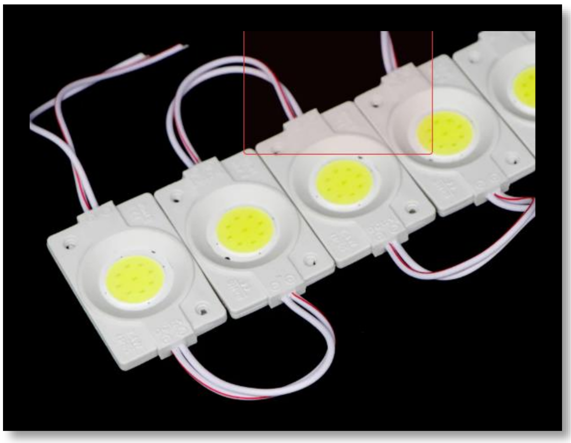

Fig 4.2.11

This DC 12V 2.4W Coin COB High Brightness Waterproof Injection Module with Clear Lens is a compact light source measuring approximately 600mm long, 46mm wide, and 5.7mm thin (excluding wires). Each individual module within the unit is 46mm long and 30mm wide. It contains 9 LEDs and requires a 12V power source to operate with a maximum power rating of 2.4W. Exceeding the 12V input will damage the product. The back of the entire module is equipped with 3M self-adhesive tape for easy mounting, and it boasts a waterproof IP67 rating.

4.2.12 Stand Alone 56 Teeth Gear

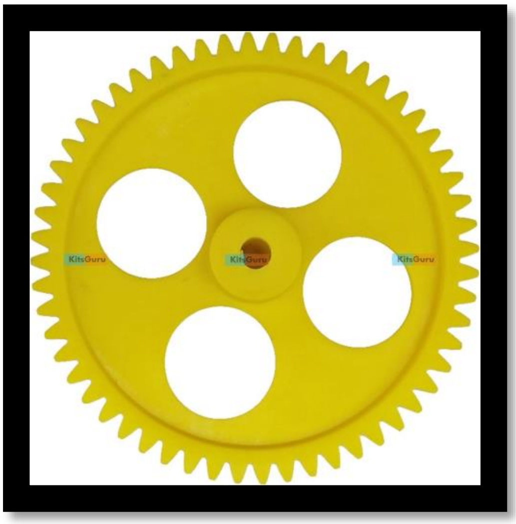

Fig 4.2.12

A 56-tooth gear rack designed to convert rotary motion into linear movement. It's made from a square or round rod with straight teeth cut into one surface and works in conjunction with a 6mm shaft and a meshing pinion gear (both likely sold separately). This rack and pinion system (the combined term for gear rack and pinion) has a thickness of 12mm at the teeth portion and an overall outer diameter of 85mm. The teeth are spaced at a pitch of 2mm for precise linear movement control.

4.2.13 Stand Alone 14 Teeth Gear

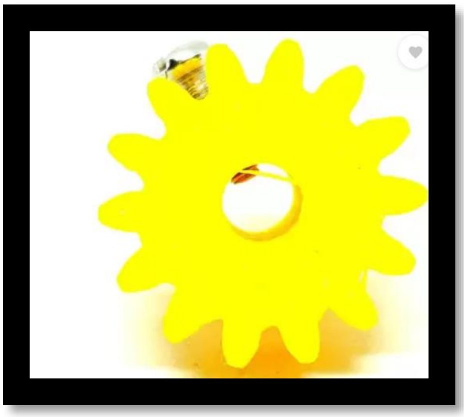

Fig 4.2.13

The term 14 standalone gear has two possible meanings, 14 individual gears, each with its own size, tooth count, and purpose, potentially used for intermeshing, rack and pinion setups, or as idler gears. Alternatively, it could describe a single unit with 14 gear selections, like a bicycle shifter for varying speeds or a multi-stage gearbox in power tools offering different torque levels.

4.2.14 100µ Capacitor

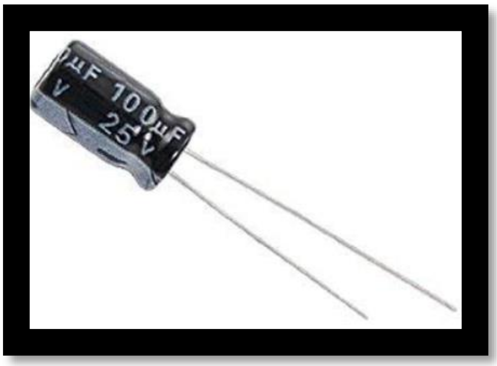

Fig 4.2.14

This 100µF capacitor, manufactured by Electrobot, is an electrolytic type specifically designed to handle a maximum voltage of 25 volts. Its key feature is its capacitance of 100 microfarads (uF), which essentially acts like a tiny electrical reservoir. This allows it to store electrical charge, making it ideal for applications like filtering out unwanted noise or smoothing out fluctuations in voltage within a circuit. These fluctuations can disrupt electronic components, so the capacitor acts as a buffer, absorbing and releasing the charge to maintain a more stable voltage level. This Electrobot capacitor is constructed with metal plates as electrodes, separated by an electrolytic solution, making it a common choice for various electronic projects.

4.2.15 1000µ Capacitor

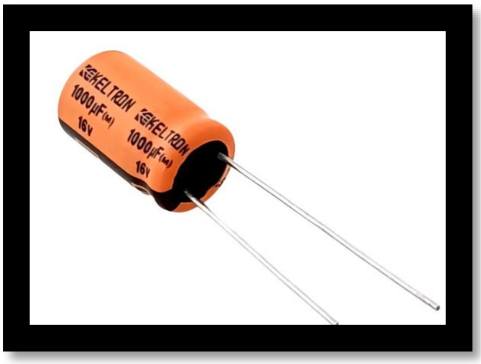

Fig 4.2.15

This 1000 µF electrolytic capacitor designed for use in DC circuits with a maximum voltage of 16 volts. It has a compact radial design with a diameter of approximately 10 millimeters and a height of 16 millimeters. The leads are spaced 5 millimeters apart and have a diameter of 0.6 millimeters. This capacitor is well-suited for applications requiring temporary storage of electrical charge, such as filtering or smoothing voltage fluctuations, and can operate effectively at temperatures up to 85 degrees Celsius.

4.2.16 Relay-Sugar Cube

Fig 4.2.16

Relay-Sugar Cube is an electromagnetic device that is used to isolate two circuits electrically and connect them magnetically. They are very useful devices and allow one circuit to switch to another one while they are completely separate. They are often used to interface an electronic circuit (working at a low voltage) to an electrical circuit that works at very high voltage. These relays can be used for switching High voltage 250 Volt (VAC) devices and has a current rating of up to 7 amperes.

CHAPTER 5

SOFTWARE IMPLEMENTATION

The code is essential for monitoring the speed of the wind and to note down the generating voltage. The speed of the wind is displayed in rpm and the voltage generated is displayed in volts on the lcd display. This code hence helps us to be aware of the situations how the speed of the wind keeps fluctuating.

5.1 Algorithm

(1) Initialization

- Initialize the LCD display (16 characters, 2 rows).
- Start serial communication at 9600 baud.
- Set pin 11 as output and turn it on (HIGH).
- Display "INITIALIZING..." on the LCD.
- Attach the servo motor to pin 6 with a minimum pulse width of 1000 microseconds and a maximum of 2000 microseconds.
- Set the servo motor position to 0 degrees (neutral).
- Print "H" to the serial monitor (commented out delay can be used for testing).

(2) Main Loop (loop())

- Call the WAITRPM() function to measure and display the RPM on the serial monitor.
- If the RPM is between 10 and 70:
- Set the servo motor position to 10 degrees (slightly open).
- Loop 15 times:
    - Read the voltage from analog pin A0 and convert it to volts.
    - Clear the LCD display.
    - Print "Gen Volt: [Voltage]V" on the first line of the LCD.
    - Print "Axial Motor ON" on the second line of the LCD.
    - Delay for 1 second.

- Set the servo motor position back to 0 degrees (neutral).
- Otherwise (RPM is not between 10 and 70):
    - Read the voltage from analog pin A0 and convert it to volts.
    - Clear the LCD display.
    - Print "Gen Volt: [Voltage]V" on the first line of the LCD.
    - Print "Axial Motor: OFF" on the second line of the LCD.

(3) RPM Measurement Function (WAITRPM())

- Check if the signal on pin 12 is HIGH.
- If it's HIGH, wait until it goes LOW (rising edge detection).
- Start a timer (store the current time in milliseconds).
- Wait until the signal goes HIGH again (falling edge detection).
- Stop the timer and record the elapsed time in milliseconds.
- Calculate the RPM using the formula RPM = (60000 / (float(T2 - T1))).
- If the calculated RPM is negative, set it to 0.
- Print the RPM value to the serial monitor.

5.2 ARDUINO NANO Programming

The Arduino Nano is been programmed using the Arduino IDE Platform by utilizing the Arduino C language programming. The complete program is given as follows:

```
#include <LiquidCrystal.h>
#include<Servo.h>
Servo AxialMotor;
const int rs = 3, en = 2, d4 = 7, d5 = 8, d6 = 9, d7 = 10;
LiquidCrystal lcd(rs, en, d4, d5, d6, as);
int RPM = 0;
int i = 0;
void setup() {
  lcd.begin(16, 2);
  Serial.begin(9600);
  pinMode(11, OUTPUT);
```

```
  digitalWrite(11, HIGH)
  ;
  lcd.print("INITIALIZING...");
  AxialMotor.attach(6, 1000, 2000);
  AxialMotor.write(0);
  Serial.println("H");
  //  delay(10000);
  //  AxialMotor.write(0);
  //  Serial.println("L");
  //  delay(10000);
  //  AxialMotor.write(180);
  //  delay(1000);
  //  AxialMotor.write(0);

  //  delay(1000);
  //  delay(1000);
}

void loop() {

  //  while (1) {
  //    if (Serial.available()) {
  //      int C = Serial.parseInt();
  //      AxialMotor.write(C);
  //      Serial.print(">>");
  //      Serial.println(C);
  //    }
  //    delay(500);
  //  }

  // delay(1000);
  WAITRPM();
  if (RPM > 10 && RPM < 70) {
    AxialMotor.write(10);
    for (i = 0; i < 15; i++) {
      float Voltage = (float(analogRead(A0)) * (5.0 / 1023.0)) * 11.0;
      lcd.clear();
      lcd.print("Gen Volt: " + String(Voltage ) + "V");
```

```
      lcd.setCursor(0, 1);
      lcd.print("AxialMotor ON");
      delay(1000);
    }
    AxialMotor.write(0);
  }
  else {
    float Voltage = (float(analogRead(A0)) * (5.0 / 1023.0)) * 11.0;


    lcd.clear();
    lcd.print("Gen Volt: " + String(Voltage ) + "V");
    lcd.setCursor(0, 1);
    lcd.print("AxialMotor: OFF");


  }
}


void WAITRPM() {

  if (digitalRead(12)) { //IF HIGH
    while (!digitalRead(12));//Wait to go LOW
    int T1 = millis();
    while (digitalRead(12)); //wait to go HIGH
    int T2 = millis();
    RPM = (60000 / (float(T2 - T1)));
    if (RPM < 0) {
      RPM = 0;
    }
    Serial.println(RPM);
  }


}
```

CHAPTER 6

RESULTS AND DISCUSSION

The described setup outlines the connection and components of a system incorporating a gear mechanism between an axial (booster) motor and a generator, intended for use with an H-Rotor Vertical Axis Wind Turbine (VAWT).

The axial motor serves as a booster to augment the rotation of the wind turbine, enhancing its efficiency, especially during periods of low wind speed. The generator, connected to the wind turbine, converts mechanical energy from the turbine's rotation into electrical energy. The circuit board acts as the central control unit of the system, housing a controller responsible for managing the operation of various components. The LCD display provides real-time monitoring and feedback on system parameters such as turbine speed, power output, and operational status.

Fig 6.1 Front View of the model

The six rectifiers are electronic devices used to convert alternating current (AC) to direct current (DC). In this context, they likely serve to rectify the AC output from the generator into a stable DC output suitable for charging batteries or powering DC loads. The relay functions as a switch to activate the axial (booster) motor when required. It is controlled by the controller on the circuit board based on predetermined criteria such as wind speed, power demand, or battery state of charge. The capacitor is utilized to smoothen the waveform of the electrical output, reducing fluctuations and ensuring a more stable supply of power to connected loads.

Positioned at the bottom of the VAWT body, the Hall Effect sensor detects the rotational speed of the turbine blades. This information is fed back to the controller, allowing it to regulate the operation of the system based on actual wind conditions and turbine performance. The DC load represents any electrical device or system that consumes the generated electrical power. This could include lighting systems, appliances, or other electronic equipment powered directly by the wind turbine system.

Overall, this interconnected system enables the efficient generation and utilization of electrical power from the H-Rotor VAWT, integrating various components to optimize performance, monitor operation, and ensure reliability under varying wind conditions.

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(rpm)	Voltage(V)	Current(A)	Input Power(W)	Output Power(W)	Efficiency (%)
56	2.26V	0.103	0.059	0.23	25.65
110	2.47V	0.148	0.117	0.365	32.05
157	2.53V	0.152	0.167	0.3754	44.48
206	3.12V	0.160	0.219	0.3952	55.41
268	3.39V	0.175	0.285	0.432	56.97
317	3.45V	0.234	0.338	0.577	58.57

Table 6.1. Tabulated Results

In the above Table 6.1, 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.

The recorded characteristics include speed, voltage, current, input power, output power, and efficiency, all of which provide valuable information on the turbine's functionality and efficiency.

The speed, measured in revolutions per minute (rpm), demonstrates the rotating velocity of the turbine blades, which is critical for determining the capacity to collect wind energy.

Meanwhile, the voltage and current columns disclose the electrical properties of the turbine's output, offering insight on the amount and flow of power produced. These metrics constitute the basis for understanding the turbine's electrical performance.

The input power column quantifies the electrical power consumed by the turbine system, which is derived using the product of voltage and current readings. In contrast, the output power column displays the turbine's electrical power output, demonstrating its efficiency in transforming wind energy into useful electricity.

This information is critical for determining the turbine's overall efficiency and ability to satisfy energy demands. Furthermore, the efficiency % calculated from the ratio of output power to input power is a good indicator of the turbine's performance efficiency. Higher efficiency ratings indicate the best use of wind energy, whilst lower values may indicate opportunities for improvement or optimization in the turbine's design or operation.

Testing in a controlled indoor laboratory setting provides accurate measurement and analysis of wind turbine performance parameters. These findings are a significant resource for academics, engineers, and stakeholders working on wind energy technology development. By examining the data in Table 6.1, insights may be acquired on the turbine's operating behaviour, efficiency trends across different speeds, and prospective routes for improving performance or efficiency. Ultimately, these insights help to advance wind energy technology and accelerate the shift to sustainable renewable energy options.

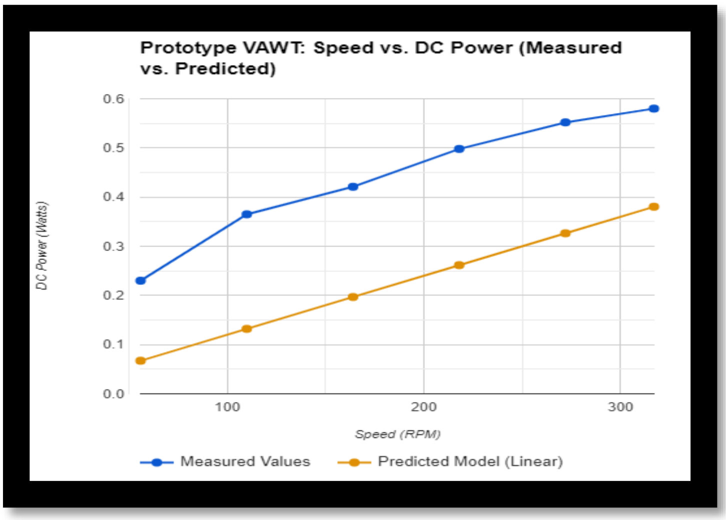

Fig 6.2 Plot of the model

The accompanying graph illustrates the relationship between turbine speed and DC current for a prototype vertical axis wind turbine (VAWT) by comparing measured values with predictions based on a linear model. The x-axis represents turbine speed in revolutions per minute (rpm), ranging from 0 to 300 rpm, while the y-axis represents direct current in kilowatts (kW), ranging from 0 to 0.6 kW. The graph has two lines: a blue line that shows the measured values, and an orange line that represents the predictions of the linear model. The blue line shows a non-linear trend, where the DC current increases at an apparently accelerating rate as the turbine speed increases.

In contrast, the orange line corresponding to the linear model shows a continuous increase in power as the turbine speed increases. The graph highlights the difference between the actual measured power of the VAWT and the predictions of the linear model, which is particularly evident at higher speeds. This indicates that the actual efficiency of the turbine exceeds that predicted by the simplified linear model. Such findings highlight the importance of empirical measurements in understanding the actual behavior of wind turbine systems. The observed non-linear relationship between turbine speed and power indicates that there are other factors influencing turbine efficiency in addition to the linear model. These insights emphasize the importance of thorough empirical analysis in turbine design and optimization of energy production efficiency of renewable energy systems.

CHAPTER 7

FUTURE SCOPE AND CONCLUSION

Utilizing data sets for VAWT performance improvement holds immense potential. Engineers can refine blade designs, rotor arrangements, and generator parameters to optimize energy capture and conversion. Researchers can leverage sophisticated modeling and computational fluid dynamics simulations to predict turbine performance under various wind conditions. This data-driven approach leads to reliable and consistent designs that maximize energy output.

VAWT control systems offer exciting possibilities for innovation. Insights from experimental data can be used to develop advanced control algorithms and feedback systems. Predictive or adaptive control techniques could enable real-time monitoring and adjustments to turbine performance based on environmental conditions and energy demands. Such advancements would not only enhance overall turbine efficiency but also improve grid integration and stability, facilitating wider wind energy adoption.

Exploring new materials and production processes for VAWT components is another promising area. Engineers can experiment with lightweight yet durable materials and novel production methods to create more efficient, reliable, and cost-effective turbine blades and support structures. Additionally, material science advancements might lead to self-healing materials or coatings, boosting the durability and lifespan of VAWTs, ultimately reducing maintenance and operational costs.

Integrating VAWTs into hybrid energy systems presents significant potential. Combining VAWTs with other renewable sources like solar photovoltaics, micro-hydro turbines, and energy storage devices can create robust and sustainable energy solutions. Hybrid systems offer several advantages, including increased energy reliability, enhanced grid stability, and improved resource utilization. By exploiting the complementary nature of diverse renewable sources, hybrid systems can mitigate intermittency and provide a more constant and reliable energy supply, contributing to a cleaner and more sustainable energy future.

This research addresses the challenges of continuous wind power harvesting by proposing a unique solution - a VAWT system with a booster motor. Recognizing wind's intermittent nature, this approach aims to overcome this limitation by integrating a booster motor with the generator, enabling the turbine to function even during periods of low wind. Experimental results demonstrate successful and consistent electricity generation by the VAWT using this innovative technique, highlighting its durability and adaptability to various environmental conditions.

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APPENDIX

I.PAPER PROCEEDINGS

International Journal of All Research Education and Scientific Methods (IJARESM),
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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. Byadding 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 productionand 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 andthe unstable aerodynamic model are coupled using beam theory by the authors in order to provide the system's dynamicresponse. 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 thatwhile 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 drivesystem, 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

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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

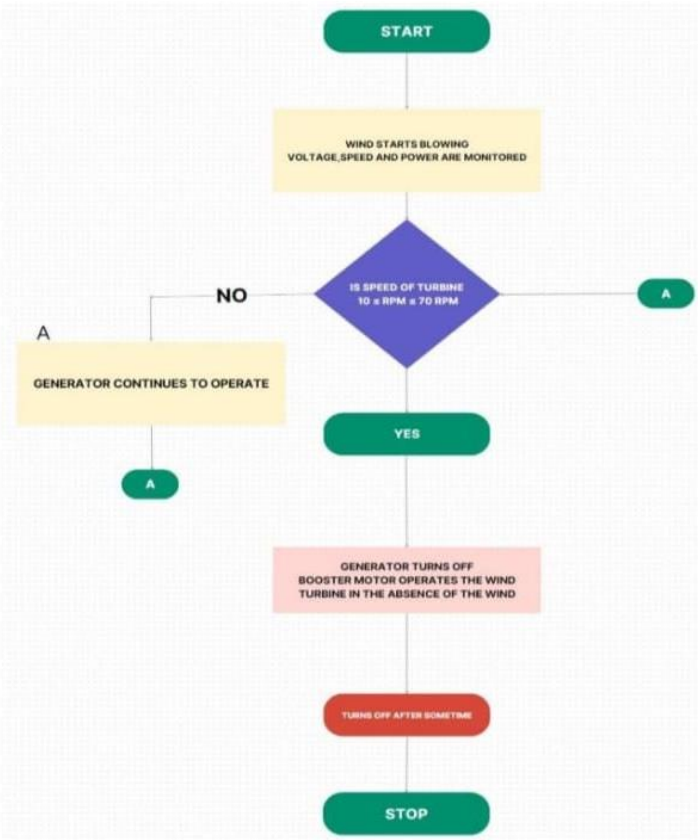

Fig 1. Flowchart of the proposed model

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 certainduration until and unless the speed of the wind is greater than 70 rpm ,the booster motor keeps running and once the

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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

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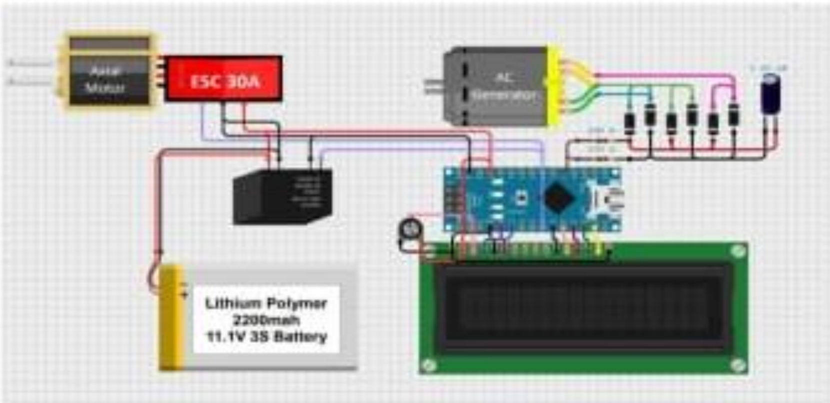

Fig 4. Circuit diagram for hardware implementation

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(rpm)	Voltage(V)	Current(A)	Input Power(W)	Output Power(W)	Efficiency (%)
56	2.26V	0.103	0.059	0.23	25.65
110	2.47V	0.148	0.117	0.365	32.05
157	2.53V	0.152	0.167	0.3754	44.48
206	3.12V	0.160	0.219	0.3952	55.41
268	3.39V	0.175	0.285	0.432	56.97
317	3.45V	0.234	0.338	0.577	58.57

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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II. COST ANALYSIS

SL No.	Components	Price
1	Arduino Nano	235
2	Arduino Nano Cable	145
3	LCD Display 16*2	159
4	New Generator Three-Phase Miniature Double Bearing Mute Inner Rotor Dc Brushless Motor High Voltage Dynamo	500
5	Booster Motor	254
6	56 Teeth Gear	102
7	14 Teeth Gear (Set Of 4)	256
8	4.4 Inches PVC Pipe	198
9	Plywood	800
10	PCB Board	80
11	Li Polymer 2200 mAh, 11.1 V	1758
12	Resistors	48
13	Capacitors	559
14	Relay	57
15	Miscellaneous	3000
	Total Cost	8,151/-

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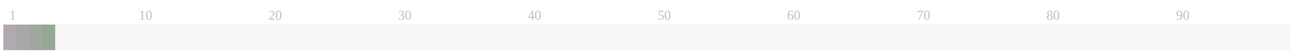

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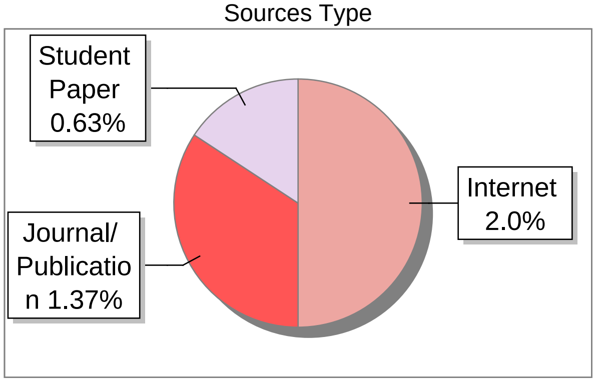

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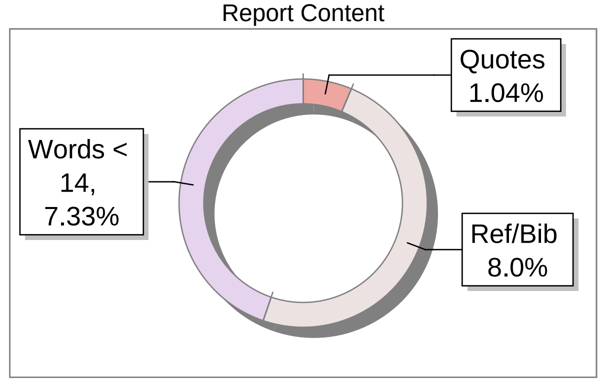

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3	astesj.com	<1	Internet Data
4	DESIGN AND COST OPTIMIZATION OF VERTICAL AXIS WIND TURBINE FOR P By 16VE1D0418 - 2018, jntuh	1	Student Paper
5	journals.pan.pl	<1	Internet Data
6	qdoc.tips	<1	Internet Data
8	sportdocbox.com	<1	Internet Data
9	www.northerngasnetworks.co.uk	<1	Publication
10	www.frontiersin.org	<1	Publication