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Design and manufacturing of Vertical Axis Wind Turbines (VAWTS) with gates and Control using Arduino Technique

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ABSTRACT: Using Sketch up layout 2018, a vertical wind turbine was designed, manufactured using a CNC laser cutting machine and controlled by the fritizing beta software (version 0.93). During the manufacturing process, acrylic material is used in the designed parts. The gates have been used in current research to monitor the amount of air and the speed of the turbine entering the six-type turbine blades. The speed of the turbine was set in relation to the change in wind speed (wind energy), which resulted in the stability of the electrical generation system in terms of voltage and frequency (AC), the reduction of economic costs, the regulation of high currents by means of the controller, in addition to the control of the maintenance of the turbine. It became noticeable from experiments that the speed over a period of time was constant, which was approximately equal to 215 rpm.

KEYWORDS: Vertical Axis Wind Turbines (VAWTS), gates, turbine speed.

INTRODUCTION

Continuous environmental changes are likely to lead to global warming, as strategic stocks run out from the oil and the constant threats of the possibility of a problem in obtaining electric power, are all factors pushed to think about alternative energies including wind. The design of the pneumatic turbines is not easy to manufacture For the purpose of operation and control of turbine speed with wind in economic and environmental conditions with ease in mind Implementation when advanced technology is not available. The capacity that the wind has to move objects, that is, the kinetic energy that air has as a result of motion, is wind energy. Wind turbines, which are devices that transform wind kinetic energy into mechanical energy, convert wind energy into electrical energy. It is energy that can be used directly for producing electricity in pumps or turbine rotations. Increased awareness of changes in global climate has increased the importance of renewable energies and increased demand for wind energy.

Different turbines have been built in various shapes around the world from the beginning of wind turbine technology to utilize wind energy and turn it to other types of energy. There are many ways to categorize wind turbines, but the rotational axis classification, which is either horizontal or vertical, is the most common and widely used type. At present, a specific style, known as the Horizontal Axis Wind Turbine (HAWT), dominates the blades. The axis of rotation in this form is parallel to the field, and this axis is usually parallel to the wind stream. When the rotor shaft is mounted vertically as a type of wind turbine, a vertical axis wind turbine (VAWT) is easier to maintain and mount, as the clutch and generator can be positioned at the bottom of a (VAWT) where it is low to the ground. There is no need to point it in the wind, which is another advantage of this setup [1]. Despite these benefits, VAWT has faced many challenges, from the early lift-based Darrieus rotors and later cyclo-turbines to the drag-based Savonius rotor, including low peak performance , low starting torque, pulsed torque, limited operating range and dynamic stability issues [2-4]. Considerable researches have taken place on Vertical Axis Wind Turbines (VAWTS) control for different situations.

Zhenzhou et al in 2018, In order to optimize the straight-bladed Vertical Axis Wind Turbine (VAWT) peak power coefficient by expanding the azimuthal angle of the band blade with maximum aerodynamic torque rather than increasing the maximum torque, a new variable pitch (VP) system has been developed [5]. To evaluate the loss of the blade edge, the effects of the new technique are exploited using Prandtl's mathematics and the Double Multiple Stream Tubes (DMST) model. A comparison of the influences of six factors between FP-VAWTs and VP-VAWTs operating at four TSRs, including drag, lift, torque, angle of attack (AoA), power output and resulting velocity: (4, 4.5, 5, and 5.5). The VP-blade has a larger azimuthal zone with the maximum AoA, drag, lift and torque in the upwind half-cycle compared to the FP blade, and generates the same two higher maximum values in the downwind half-cycle. Power delivery in the swept turbine area changes from the arched FP-VAWT shape to the rectangular VP-VAWT shape. In a revolution, the new VP technique significantly enlarges the highest-performance region of the blade and achieves (18.9 percent) VAWT peak power coefficient growth at the optimum TSR.

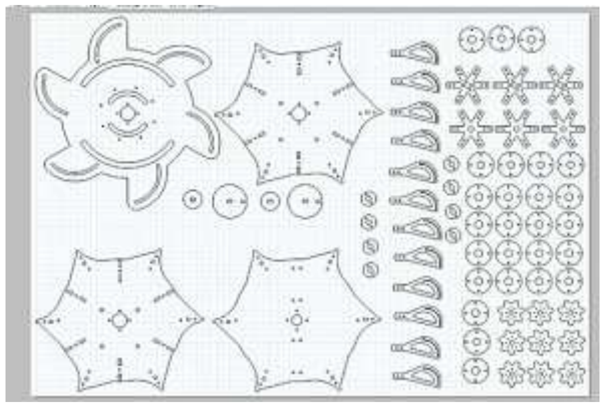
1V. Kumar et al. an optimal pitching action was developed in 2018 that minimizes the periodic disruption of turbine blades (VAWTs) without affecting their generation of electricity [6]. For the recursive identification of model parameters (VAWT), the Subspace Predictive Repetitive Control (SPRC) method along with a LQ Tracker has been used and an optimal control rule is adequately developed. Base functions were used in order to minimize the dimensionality of the control problem. Combined with LQ Tracker, the data-driven SPRC technique has great potential for simulation outputs to minimize turbine loads on VAWTs. It would be beneficial to expand a wind farm's situation analysis and to study the controller 's effectiveness in maximizing the wind farm. Abdolrahim et al. Using Computational Fluid Dynamics (CFD) measurements, the variations in turbine moments and loads, as well as the experienced attack angle, shed voracity and boundary layer events (leading edge and trailing edge separation, laminar-to-turbulent transition) were studied in 2017 as a function of pitch angle [7]. Unsteady Reynolds-Averaged Navier-Stokes (URANS) calculations utilized to investigate (-7˚ to +3˚) pitch angles whereas the 4-equation transition SST model is utilized to modeled the turbulence. The results present increase in CP of about (6.6 %) can be produced using (-2˚) pitch angle at (4) tip speed ratio. In addition, A pitch angle adjustment is seen to transfer instantaneous moments and loads between the turbine's downwind and upwind halves.

Akshay Aggarwal et al. in 2016 described an attempt for optimizing (VAWT) performance utilizing active blade pitch control [8]. The wind turbine H-type Darrieus (VAWT), which works on the wind lift power, was constructed. Active Pitch controlled (VAWT) is done with individual pitch control of each blade along with vertical roller bearings in the device to obtain from the wind turbine setup the maximum power harnessed coefficient and increase the performance by (12.5 percent). According to the surface profile, the aerodynamic model is chosen. The most suitable category in which NACA 0018 aero foil design parameters were selected for the design of the (VAWT) blade was shown to be the NACA 4 digit series. M. Mauri et al. in 2015, the design of an H-Darrieus (VAWT) pitch-controlled lift of 3-3 m (diameter / height) for urban installations was announced [9]. This kind of wind turbine was chosen for the possible feature modifications with regard to the classical fixed-pitch concept, such as the efficiency of active pitch control and self-starting mode for standalone applications. With regard to design optimization, preliminary outputs were presented.

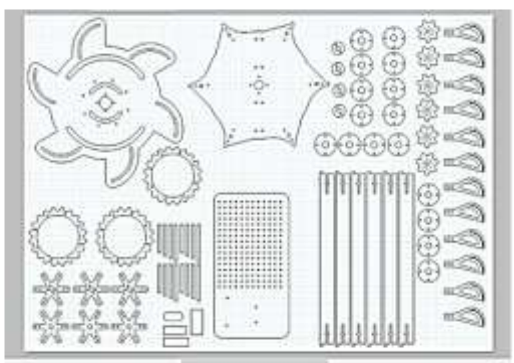
Prasad Chougule and Soren Nielsen, a summary of several pitch control systems and the self-acting pitch mechanism architecture was addressed in 2014 [10]. Modeling a pitch regulation linkage mechanism (VAWT) multi-body technique using MSC software. According to the Double Multiple Stream Tube technique, aerodynamic loads are projected from a mathematical model. For the blade design, an acceptable airfoil that functions at a low Reynolds number is selected. It also focuses on (VAWT) commercialization, which incorporates the self-acting pitch control system. A 500 Watt (VAWT) has been produced and it is planned that the self-acting pitch control mechanism will be implemented in a real model. Peter J. Schubel and Richard J. Crossley, a comprehensive analysis of the existing state of the art for the design of wind turbine blades, consisting of propulsion, maximum theoretical performance, functional efficiency, blade loads and the design of HAWT blades, was presented in 2012 [11]. The analysis provides a full picture of the wind turbine blade architecture and presents the almost exclusive use of horizontal axis rotors for modern turbine supremacy. For a modern wind turbine rotor, the aerodynamic design concepts are extensive, including the selection of aero foil, the form / sum of the blade plan and optimum angles of attack. The main objective of this study is to design a turbine that can be manufactured and operate in economic and environmental conditions taking into accounts easy of implementation due to lack of advanced technology.

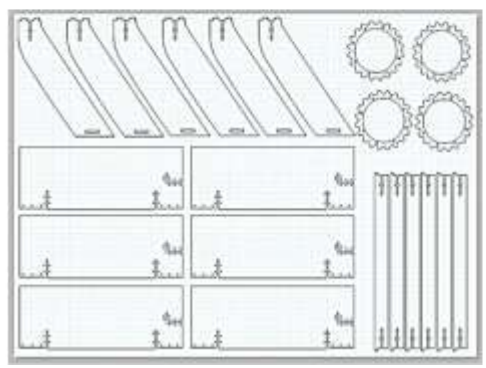
TURBINE DESIGN

Vertical Axis Wind Turbines has been designed using Sketch up layout 2018.Figure (1-a), (1-b) and (1-c) demonstrated the detail parts of turbine design using (Sketch up layout 2018). Figure (2) illustrate the top view of Vertical Axis Wind Turbine (VAWT).



(a)





(b) **(c)**

Figure 1. (a, b, c) demonstrate detailed parts of turbine design using (Sketch up layout 2018)

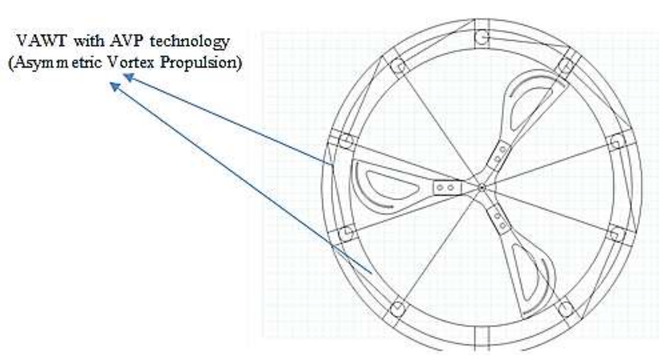


Figure 2. Top View of Vertical Axis Wind Turbine (VAWT)

MANUFACTURING APPROACH

The designed parts have been manufactured using CNC laser cutting machine as shown in Figure (3).

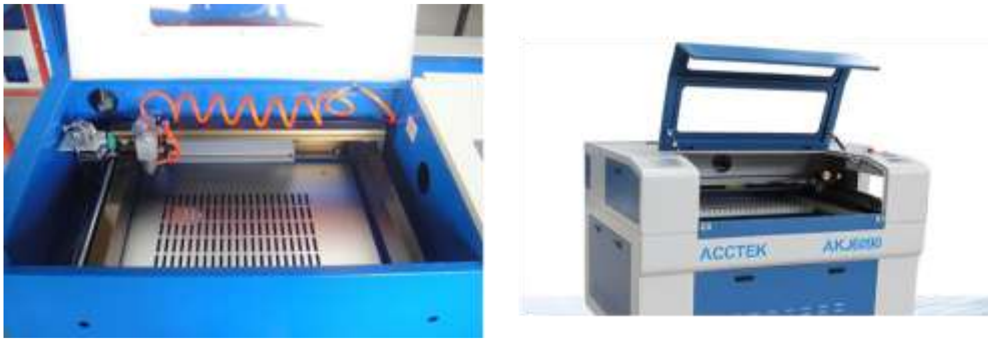


Figure 3. CNC laser cutting machine

MATERIEL USED

The materiel used in manufacturing the designed parts is Acrylic with dimension of (120× 80 mm) and cutting into 4 mm thickness. Figure (4); illustrate the connected parts of (VAWT configuration).

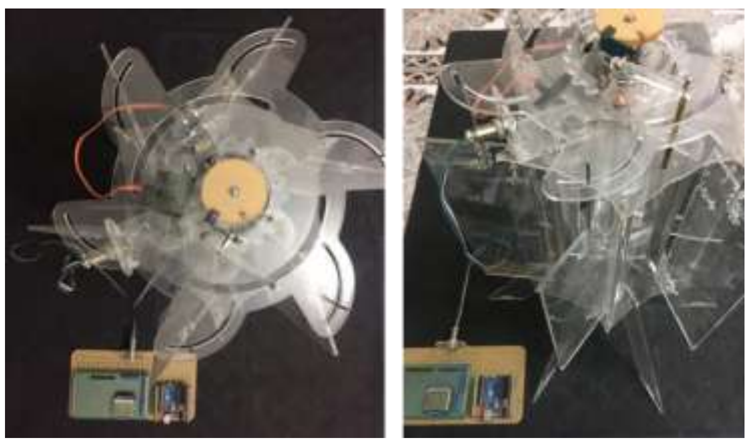


Figure 4. The connected parts of (VAWT configuration)

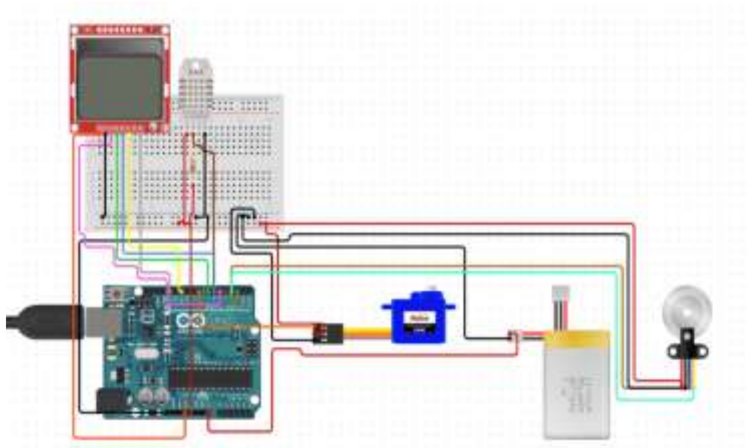


Figure 5. Arduino as electronic circuit

CONTROLLING SIMULINK

This work has been controlled using fritizing beta program (version 0.93). Six parts have been used in controlling turbine wind blades:

1. Photoelectric Speed Wheel Encoder.
2. Arduino as shown in Figure (5).
3. Servo motor.
4. Graphic LCD 84x48 - Nokia 5110.
5. DHT22/11 Humidity and Temperature Sensor.
6. Lithium Polymer Battery 7.4v.

RESULTS

A comparison was made between the speeds as shown in the table (1). Figure (6), illustrate speed with time relation.

Table 1. HA data at different values.

Time	Wind Speed (m/sec) By us Variometer	RPM Without AVP	RPM With AVP Without control	RPM with AVP & with Control
1	1	0	82	83
2	2	0	215	215
3	3	125	309	216
4	4	220	430	216
5	5	286	509	217
6	6	386	620	216
7	8	451	727	216
8	10	480	813	215
9	12	508	843	215

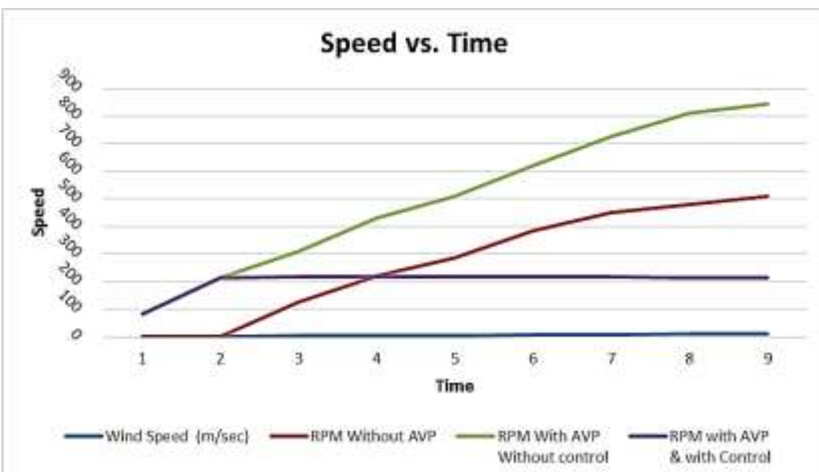


Figure 6. Speed with time relation

CONCLUSION

1. In this research, consideration was given to the ease of experimenting with certain variables in order to test them In order to achieve the best efficiency and low cost, to choose the best position of the turbine blades.

2. Use Arduino to control the speed of the wind turbine by controlling the gates which enter the turbine. If the speed is high we reduce the opening of the turbine gates until the speed of the turbine is fixed or vice versa if the air speed is low we make the turbine gate open.
3. A program was created to calculate the speed needed for the turbine, and complete control of the turbine gates was carried out at the same time.
4. From experiments in table (1), it's clear that the speed was constant over a time, which was approximately equal to 215 rpm.

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