Design and fabrication of Butterfly wind mill machine

Hariprasath Thangavelu[1*], Ranjith Subramani[2],SathishD[3], Ranjith Kumar Ramamoorthy[4]
[1,2,4]UG Student, Department of Mechanical Engineering, K.S Rangasamy College of Technology,Thiruchengode,637215, Tamil Nadu, India.*
[3]Assistant Professor,Department of Mechanical Engineering,K.S Rangasamy College of Technology, Thiruchengode, 637215, Tamil Nadu, India.
Corresponding Author Email:imusingmobile@gmail.com

Abstract
The aim of this paper is to generate the electricity with the help of butterfly bladed wind mill. The butterfly bladed wind mill is use for generating the D.C. power. Power generation is depending on the velocity of the wind. A well-known renewable source of energy, Wind energy is obtained with the help of Wind Turbines. Wind turbine is a device that converts the Kinetic Energy from the wind into mechanical energy. If the mechanical energy is used to produce electricity, then that device is called as wind generator. Here the blades are designed to reduce the opposing forces acting on the surfaces of the blades. When the air strikes in between the blades gap, the blades are opened and started to rotate. After completing 180, the air acting on the same direction, strikes the outer surface of the butterfly type blades. Due to the forces striking on the blade surfaces, the blades are closed. So that the area of contact of the blades are reduced i.e., opposing forces are reduced. The speed of the turbine will not affect, because there is a reduction in opposing forces. After reaching its original position, the blades are again opened and rotated. Due to the repeated rotation of the three blades, the continuous rotation will occurs. Finally, the electrical power will be take out from dynamo connected with the turbine shaft.

Keywords: *Butterfly bladed turbine, Wind power, D.C Supply, Power control.*

1. Introduction

The cost of wind-power generation has been gradually reduced by enlarging the size of wind turbine rotors and now wind has become one of the main power sources in the world. The global cumulative installed capacity of wind power has been growing and exceeded 539 GW at the end of 2017 [1]. However, the introduction of large-size wind turbines often faces problems such as concerns about spoiling the scenery and hurting the natural environment. Therefore, time consuming environmental research is needed before introduction of large-size wind turbines [2]. On the other hand, small-size wind turbines can be installed easily in various places due to their less important impact on the environment and easy transportation. Therefore, small-size wind power generation is expected to become a clean energy source at various places where it is difficult to introduce large-size wind turbines due to specific reasons or where a site is not suitable for photovoltaic power generation. In particular, the demand for small wind power systems might be large at high latitudes that are abundant in wind energy compared to solar energy and in dry lands in which electricity is not used sufficiently in people’s daily lives. However, since the wind energy captured by the small rotor is not large, generally speaking, the cost of energy of a small wind-power system is expensive and the market has not grown in comparison with large-size wind turbines.

Changing the viewpoint, although the mainstream of wind power is large-size propeller-type horizontal axis wind turbines (HAWTs), small-size vertical axis wind turbines (VAWTs) have the possibility to be suitable for installation in places near a living environment or to lead to cost reduction due to the simple structure and non-dependence on wind direction. Therefore, many studies on small VAWTs have been conducted recently. VAWT which featured an armless rotor, i.e., a rotor without spokes, with looped blades was invented. The VAWT was named the “Butterfly Wind Turbine (BWT)” as the rotor is shaped like a butterfly [6]. The BWT would be expected to have small aerodynamic resistance and small blade-tip loss due to the armless structure.

Fig 1.Butterfly wind turbine model

The shape of the BWT was originally considered to have a generator installed near the center of the rotor and its rotational axis could be short in order to avoid large vibration. Although the blades of experimental wind turbines were initially made of plastics or composite materials, adoption of aluminum blades made by extrusion molding gave the possibility of mass production and cost reduction of the BWT [2]. The purpose of this study is to prove the efficiency of BWT proposed here.

2. Literature Review

Liu et al., developed a novel gear transmission optimization model based on dynamic fatigue reliability sensitivity to predict the optimal structural parameters of a wind turbine gear transmission. In the model, the dynamic fatigue reliability of the gear transmission is evaluated based on stress-strength interference theory. Design variables are determined based on the reliability sensitivity and correlation coefficient of the initial design parameters. The optimal structural parameters with the minimum volume are identified using the genetic algorithm in consideration of the dynamic fatigue reliability constraints. Comparison of the initial and optimized structures shows that the volume decreases by 3.58% while ensuring fatigue reliability. This work provides new insights into the RBDO of transmission systems from the perspective of reliability sensitivity. [3]

Divakaran et al., studied the effects of the helix angle of blades in the aerodynamic performance of VAWT using 3D numerical simulations. Three different helix angles of 60°, 90°, and 120° of a three-bladed VAWT operating across different tip speed ratios were studied. Turbulence is modelled using a four-equation transition SST k-ω model. The 60° helical-bladed VAWT was found to be better performing in comparison with all other helical-bladed and straight-bladed VAWT. The ripple effects on the shaft are also analysed using a standard deviation plot of the moment coefficient generated by a single blade over one complete cycle of its rotation. It was observed that the greater the helix angle, the lower the standard deviation. The paper also tries to analyse the percentage of power generated by each quartile of flow and the contribution of each section of the blade. Ansys FLUENT was employed for the entire study. A comparative study between different helical-bladed VAWT and straight-bladed VAWT was carried out along with wake structure analysis and flow contours for a better understanding of the flow field. [4]

Hara et al., applied computational fluid dynamics (CFD) targeting a small-sized straight-bladed VAWT to elucidate the effects of arms on turbine performance. In the analysis, three kinds of arms with different cross-sections (NACA 0018 airfoil, 18% rectangular, circular) with the same height were added to an armless rotor. The tangential forces and resistance torques caused by the added arms were recalculated by dividing the pressure and friction influences based on the surface pressure and friction distributions obtained by the CFD on an arm or a blade. The pressure-based tangential force of an arm, regardless of the cross-section, had a tendency to increase near the connection part between the arm and a blade. Though the value was small, the friction on the rectangular arm generated a driving force, whereas the friction on the other arms generated resistance forces. The pressure-based tangential force of a blade increased for a wide region around the connection part. The friction-based tangential force of a blade dropped around the connection part of every arm-equipped rotor. [5].

3. Methodology

3.1. Study Area

The selected study area is Nanjaiuthukkuli, Erode, Tamil Nadu, where the average wind speed is 5 m/s.

DOI:10.9756/INTJECSE/V14I5.843 ISSN: 1308-5581 Vol 14, Issue 05 2022

Fig 2.Study Area

The main components that are used in the fabrication are shown in the figure below,

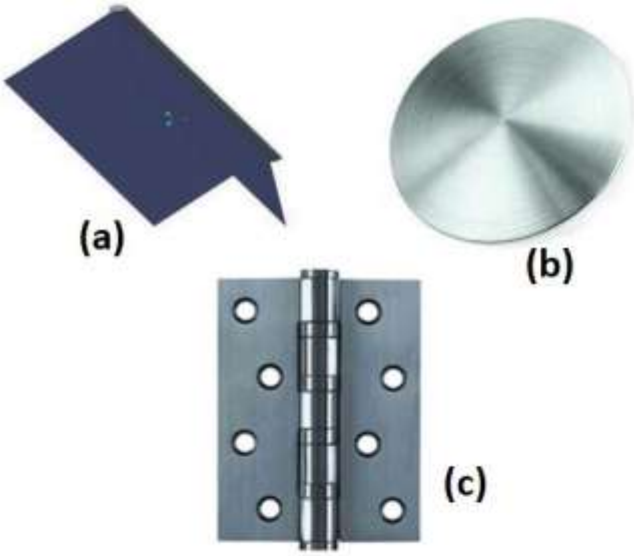

Fig 3.(a) Butterfly type turbine Blade, (b) Supporting Disc, (c) Door Hinges.

The centre of the disc is welded with the hollow shaft at the Height of 30mm from the bottom of the Shaft. The blades are hinged with the supporting rod with the help of door hinges. The three Supporting rods along with blades are fixed on the disc, and each having 1200 Angle difference between them. These three supporting rods are welded with the centre hollow shaft for rigidity. The centre hollow shaft is connected with the bottom frame with the help of ball bearing for free rotational motion. The extension of the hollow shaft is made to connect with the dynamo for producing electric power. In this project, the blades are rotates based on the vertical axis. Here the blades are designed to reduce the opposing forces acting on the surfaces of the blades. When the air strikes in between the blades gap, the blades are opened and started to rotate. After completing 1800, the air acting on the same direction, strikes the outer surface of the butterfly type blades. Due to the forces striking on the blade surfaces, the blades are closed. So that the area of contact of the blades are reduced i.e., opposing forces are reduced. The speed of the turbine will not affect, because there is a reduction in opposing forces. After reaching its original position, the blades are again opened and rotated. Due to the repeated rotation of the three blades, the continuous rotation will occurs. Finally, the electrical power will be take out from dynamo connected with the turbine shaft

Fig 4.Fabricated butterfly bladed wind turbine

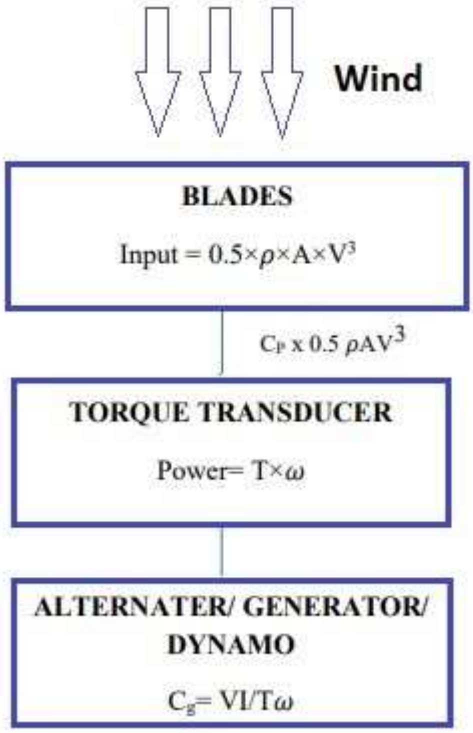

Fig 5.Block diagram of wind turbine

3.2. Mathematical Modelling

The total power available in the wind is calculated by using the following formula

$Pa = 0.5 \times A_s \times \rho \times V^3$

Where, P_a = Total power available in wind in Watts.

As = Swept area in m^2

ρ = Air density = 1.23 kg/m3 V = Wind velocity in m/s.
Swept area (A_s) = DH
Where, D = Diameter of the turbine in m.
H = Height of the blade in m.
3.2.1 Power extraction
Principally the power that the rotor can extract from the wind Pw is less than the actual available from the wind power P_a. Practically, when the turbine is placed at 5m/s inlet velocity (1) and outlet (2) is 2m/s the power that can be extracted from the wind is found by the following methodology.
The average wind speed through rotor area V_{avg}
$(V_1 + V_2)/2$
Where V1 , V2are the inlet and outlet wind speed in m/s.
The mass of airflows through the rotor area(m) = As x ρ x (V1 + V2) / 2
Kinetic energy = $mV^2/2$

4. Result and Discussion

Therefore the power extracted, P = m x ($V1^2$ - V2) / 2 , substituting the mass of air PW = ((ρ (V^2- V_2) (V_1 + V_2) x A_s))/ 4

Table 1 Power and speed according to wind speed

Sl.no	Wind Speed m/s	Tip Speed m/s	Speed RPM	Power Watts	Power Obtained watts
1	1.5	0.75	112	1.3	0.26
2	3	1.5	180	10.67	2.13
3	6	3	290	83.34	16.66
4	9	4.5	415	281.3	56.26
5	12	6	618	666.7	133.34

4.1. Power calculation

Power (P) = ½ $C_pA_s\rho V^3$

Table 2 Output voltage according to wind speed

Wind speed m/s	Torque Nm	Wind Voltage	Combined Output Voltage
1.5	0.6	1.3	6.7
3	2.48	3.2	12.6
6	9.72	5.6	16.7
9	21.87	9.2	23.4
12	38.89	9.8	26.6

The traditional horizontal axis wind turbines are turned to face the wind in order of work efficiently. The mechanism used to turn horizontal axis turbines, the yaw mechanism, isn't needed on vertical axis wind turbines. They are equally efficient whatever the wind direction. This means vertical axis turbines are more effective in areas with variable wind direction, such as built-up areas, and they save the difficult maintenance tasks associated with yaw mechanism. Horizontal axis turbines need large and heavy rotates to produce large quantities of power, and because of this wind speed needed to keep them moving is high. The vertical axis turbines can produce power even from lower wind speeds not large amounts of power, but a steady trickle can be produced. There is no getting around the fact that horizontal axis turbines are noisy when they are in full flight. However there can be issues with noise, and other maintenance problems, created by vibration if the turbines are not mounted very carefully.

5. Conclusion

Wind is a cost effective, green, renewable energy resource for power generation. A Novel design of wind turbine with improved efficiency can help us to reduce a gap between demand and supply of power. The working model of the project is combined energy source and Butterfly wind turbine system which is a good and effective solution for power generation. And basically this system involves the new design of combination of two energy system, suppose anyone source fails to generate another source will keep generating the electricity and will give the continuous power to the load. This project can also be developed by changing the number of blades and with the materials used. This idea does not require any limitations and large space like nuclear or other types of power plants, it is possible to be built in any location around the globe and produce more electricity. This type of power plant is the best solution for controlling the global warming. In this project, the opposing forces acting on the blade surfaces are reduced by re-designing the ordinary type blades into the butterfly type blades. These butterfly type blades are designed to open and close type. Due to the reduction of opposing forces on butterfly type blades, the Speed of the wind turbines will be increased. So, that the efficiency of the wind turbine has been increased, When compared to other ordinary turbines.

Finally, The authors genuinely thank AICTE, New Delhi, India for the budgetary help with completing this work under MODROB (AICTE FILE No 9_ 240/ IDC/MODROB/ policy 1/ 2019_ 20). Dated.20.7.2020

References

[1] Porté-Agel, F., Bastankhah, M., &Shamsoddin, S. (2020). Wind-turbine and wind-farm flows: a review. *Boundary-Layer Meteorology*, *174*(1), 1-59.

[2] Wen, Q., He, X., Lu, Z., Streiter, R., & Otto, T. (2021). A comprehensive review of miniatured wind energy harvesters. *Nano Materials Science*, *3*(2), 170-185.

[3] Liu, G., Liu, H., Zhu, C., Mao, T., & Hu, G. (2021). Design optimization of a wind turbine gear transmission based on fatigue reliability sensitivity. *Frontiers of Mechanical Engineering*, *16*(1), 61-79.

[4] Divakaran, U., Ramesh, A., Mohammad, A., &Velamati, R. K. (2021). Effect of helix angle on the performance of Helical Vertical axis wind turbine. *Energies*, *14*(2), 393.

[5] Hara, Y., Horita, N., Yoshida, S., Akimoto, H., & Sumi, T. (2019). Numerical analysis of effects of arms with different cross-sections on straight-bladed vertical axis wind turbine. *Energies*, *12*(11), 2106.

[6] Rahim W Design And Testing Of A Deflector Integrated Cross Axis Wind Turbine.

[7] Du, Y., Zhou, S., Jing, X., Peng, Y., Wu, H., & Kwok, N. (2020). Damage detection techniques for wind turbine blades: A review. *Mechanical Systems and Signal Processing*, *141*, 106445.

[8] Ren, Z., Verma, A. S., Li, Y., Teuwen, J. J., & Jiang, Z. (2021). Offshore wind turbine operations and maintenance: A state-of-the-art review. *Renewable and Sustainable Energy Reviews*, *144*, 110886.

[9] Stetco, A., Dinmohammadi, F., Zhao, X., Robu, V., Flynn, D., Barnes, M. &Nenadic, G. (2019). Machine learning methods for wind turbine condition monitoring: A review. *Renewable energy*, *133*, 620-635.

[10] Yuvaraja, T., &Ramya, K. (2018). Analysis of wind turbine modelling using TSMC techniques. *COMPEL-The international journal for computation and mathematics in electrical and electronic engineering*.

[11] Liu, Z., & Zhang, L. (2020). A review of failure modes, condition monitoring and fault diagnosis methods for large-scale wind turbine bearings. *Measurement*, *149*, 107002.

[12] Gao, Z., & Liu, X. (2021). An overview on fault diagnosis, prognosis and resilient control for wind turbine systems. *Processes*, *9*(2), 300.

[13] Yahya, W., Ziming, K., Juan, W., Al-Nehari, M., Tengyu, L., Qichao, R., &Alhayani, B. (2021). Study the influence of using guide vanes blades on the performance of cross-flow wind turbine. *Applied Nanoscience*, 1-10.

[14] Sun, H., Qiu, C., Lu, L., Gao, X., Chen, J., & Yang, H. (2020). Wind turbine power modelling and optimization using artificial neural network with wind field experimental data. *Applied Energy*, *280*, 115880.

[15] Menezes, E. J. N., Araújo, A. M., & Da Silva, N. S. B. (2018). A review on wind turbine control and its associated methods. *Journal of cleaner production*, *174*, 945-953.

[16] Lundquist, J. K., DuVivier, K. K., Kaffine, D., &Tomaszewski, J. M. (2019). Costs and consequences of wind turbine wake effects arising from uncoordinated wind energy development. *Nature Energy*, *4*(1), 26-34.