Design & Analysis of Savonius VAWT for 50W Rated Power output- A Review

Mr. Sachin Khandagale [1], Prof. B. G. Marlapalle[2]
[1, 2] Department of Mechanical Engineering
[1, 2] DIEMS Aurangabad , Maharashtra,India

Abstract- *The blade of wind turbine is designed by using Pro-E software. The structural feasibility is analyzed by Finite Element Analysis method. Finite Element Analysis and the computational fluid dynamics analysis are used in this project. Finite Element Analysis method is used to obtain the maximum deformation and stress experienced by the rotor blade. The computational fluid dynamics analysis is performed in order to obtain the pressure difference between the concave and convex surface of the rotor blade. A wind turbine converts the kinetic energy of the wind into electrical energy. Wind turbines come in different sizes and types, depending on power generating capacity and the rotor design employed.*

Keywords- Blade, Rotor, Pro-E software

I. INTRODUCTION

World energy use increased more than ten times before over the 20th century, predominantly from fossil fuels (i.e. coal, oil and gas) and with the addition of electricity from nuclear power. In the 21st century, further increases in world energy consumption can be expected, much for rising industrialization and demand in developing countries for the rural electrification. For solving the world energy problem and the bad effect of conventional sources of energy on environment more attention all over the world is giving on the use of renewable energy sources. Purchases of energy account for 5–10% of gross national product in developed economies. [1]

The need of renewable energy become more significant now a days due to several issues such as global environment problem, the depleting of fossil fuel thus raise the oil price as well and economic concern. In this situation, government already takes smart action in promoting, enforcing and enhancing the renewable energy by the policy or act. The study of the impact of wind energy on the future and product development should be performed to ensure that it will be very profitable to satisfy the electricity demand of the community. [2]

Wind power is the conversion of wind energy into a useful form of energy, for example to make electrical power, mechanical power, wind pumps for water pumping or drainage, or sails to propel ships etc. Large wind farms consist of hundreds of individual wind turbines which are connected to the electric power transmission system. Offshore wind farms are more frequent and powerful winds than the other available land-based installations but construction costs are considerably higher & also maintenance. Small onshore wind facilities are used to provide electricity to isolated locations and utility companies increasingly buy surplus electricity produced by small domestic wind turbines. [3] [6]

Wind turbine technology offers cost-effective solutions to eliminate costly use of conventional sources used to generate electricity. Additionally, this technology provides electrical energy without greenhouse effects or deadly pollution releases. Furthermore, wind turbine installation and electricity generating costs are lower compared to other electrical energy generating schemes. A wind turbine is the reverse of an electrical fan. A wind turbine converts the kinetic energy of the wind into electrical energy. Wind turbines come in different sizes and types, depending on power generating capacity and the rotor design employed. [4]

There are two kinds of wind turbines according to the axis of rotation to the ground, horizontal axis wind turbines (HAWT) and vertical axis wind turbines (VAWT). VAWTs include both a drag type configuration like Savonius wind turbine and a lift-type configuration like Darrieus wind turbine. Savonius wind rotor has many advantages over others in that its construction is simpler and cheaper. It is independent of the wind direction and has a good starting torque at lower wind speeds. [5]

The objectives of this research were thus to design and develop a Savonius rotor blade for 50 watt rated power output with locally available materials and compare its performance and production cost with the existing blades. The blades were made using glass reinforced fibre because of the material's light weight. This factor enabled the rotor to rotate at very low wind speeds, it is also long lasting and does not rot hence can survive in all weather conditions. A prototype rotor blade was fabricated, tested and efficiency checked. The blades are designed by the use of Pro-E software and analysed by the use of Ansys -14 software.

Ronit K. Singh et.al, [12] Small wind turbines operating at low wind speeds regularly face the problem of poor performance due to laminar separation and laminar separation bubbles on the blades. This is due to the low Reynolds number (Re) resulting from low wind speeds and small rotor size. The use of specially designed low Re airfoils permits start up at lower wind speeds, increasing the startup torque and thus improving the overall performance of the turbine. A new airfoil was designed and the performance of a 2-bladed rotor designed for low Re application fitted to an Air-X marine 400Wwind turbine was tested at a wind speed range of 3e6 m/s. The low Re rotor incorporated taper and twist to the low Re AF300 airfoil section. The pitch of the blades was varied over a range of 15_, 18_ and 20_ to study the performance and the startup wind speed. It was found that the turbine performed best at 18_ pitch angle. On an average, the wind turbine yielded a power coefficient (CP) of 0.255 at a height of 8.22 m at a wind speed of 6 m/s at 180 pitch angle. Maximum CP based on 10 s data at the free stream velocity of 6 m/s was 0.291. The cut-in wind speed based on 10 s averaged data at the optimum pitch angle was 3.24 m/s whereas the instantaneous cut-in wind speed was 2.34 m/s. In comparison with the baseline 3-bladed rotor, the new 2-bladed rotor produced more electrical power at the same free stream velocity.

Jean-Luc Menet et.al, [14] The aerodynamic behavior of slow running wind turbines of Savonius type has been largely studied, but the disparity of these studies makes it difficult to compare the results. Through an exhaustive bibliographical research, it is possible to identify the influent parameters, and to show that the aerodynamic efficiency of the Savonius rotor can be notably improved via a judicious choice of its geometrical parameters. This study suggests to use a double-stepped Savonius rotor with two paddles and two end-plates. The height of the rotor should be twice its diameter. The primary overlap ratio must be between 0.15 and 0.3 times the diameter of the paddle, whereas the secondary overlap ratio should be equal to O. This study is followed by a numerical simulation of the flow. The results of the simulation propose the optimal values for the geometrical parameters. This simulation leads us not only to precise the nature of the flow, but also to determine the aerodynamic behaviour of the rotor. The results are compared to experimental data. In particular, a prediction of the aerodynamic torques for few geometrical configurations is given. The influence of a central shaft is studied, such as the presence and the geometry of an external chassis. The influence of the Reynolds number is investigated. These considerations make it possible to define an optimal geometrical configuration.

The present study, destined to precise the aerodynamic behavior of Savonius rotors, was realized in two parts. First a bibliographical study has identified the main influent geometrical parameters. Then a numerical simulation has estimated this influence and proposed optimal values for these geometrical parameters. The results are incontestably higher values of the power coefficient i.e. the aerodynamic efficiency of the rotor. In the following, it will be obviously necessary to develop a 3-D simulation and to propose other forms of paddles to increase the global efficiency of such a rotor.

Kiran Nakil et.al, [15] in today’s life the demand on electricity is much higher than that of its production, the main objective is to produce electricity by using the force of air created by the moving vehicle in highways, and Electricity can be generated by using the VERTICLE AXIS HIGHWAY WINDMILL. This is a new unique method of power generation. In this method the windmill blade is designed in a vertical direction and it is kept at the middle of the highway divider by a series combination. The force in the middle portion is higher than the side of the road .This force will rotate the vertical turbine blade and this blade is coupled with the generator which produces electricity. In this method one additional generator is coupled to increase the efficiency. The vertical axis wind turbines are not readily available in the market and not found in India but the horizontal axis wind turbine is found. Most of the research is on experimental side on determination of mechanical power and power coefficients. Various design configurations give different power performance outputs which again depend on the wind velocity. Hence the experimental study using wind tunnel is necessary to generate the data for different wind speeds. The selection of rotor parameters plays an important role to achieve the power performance. It is also important to study the effect of combinations of rotor for different aspect ratio and number of stages to achieve maximum power performance coefficient. This research aims to develop a Savonius type Vertical Axis Wind Turbine capable to run on lower wind conditions in India.

1. Coefficient of performance (Cp) increases with velocity Kiran Nakil et al Analysis of vertical axis windmill turbine.
2. Rotations per minute (RPM) increases with increase in velocity
3. Wind potential power is higher at Pune-Nashik highway
4. The wind velocity increases consistently with increase in altitude
5. Maximum power rating was found out to be 18.8580W.

6. 1Wind thus is a reliable source of non-conventional for energy production
7. Utilization of highways for energy production fields can give out high yield potentials.

R. D. Maldonadoa et.al, In this work a detailed study of Savonius wind rotor was investigated in order to obtain the optimal characteristics. The designed Savonius wind rotor assembly was developed on CAD software. Simulations of the interaction between the flow of air and blades were developed through finite element analysis. A result of these simulations shows the velocity distribution of the profile blades. In the same way, it was obtained the profile pressure due the velocities profiles. The formations of vortices were studied with the finality to improve the performance of the Savonius rotor. Blades with different geometry and gap distance between the blades were simulated, the results shown better geometry for the blade and gap distance between blades that improved the power coefficient (Cp) of the Savonius rotor. Simulations results show that the geometry and gap distance of the blades increases the Cp about 20%. Through gap distance between the blades, the wind was directed to the surface of following blade to induce its rotation. An air deflector was located front the Savonius rotor to increase and guide the flow of air to the blades. The deflector increased the velocity of the Savonius rotor up to 32%. From the simulation results it was built a prototype Savonius wind rotor at scale 2:1 according to simulation done; field tests will be performed to check the amount of energy obtained with the changes implemented.

A.J. ALEXANDER et.al, Tests have been made in a wind tunnel on a number of Savonius rotor configurations in wind speeds of 6--9 m/s. The variables tested were blade aspect ratio, blade overlap and gap and the effects of adding end extensions, end plates and shielding. For low aspect ratios (~ 1) with no additions the efficiency was low (-0.065) but for higher aspect ratios (-5) with optimum blade configuration and shielding a maximum value of efficiency of 0.25 was obtained. Tests with three and four bladed configurations gave appreciably lower values of efficiency. A special study was made of wind tunnel corrections for blockage ratios up to 0.3.

II. CONCLUSION

A unique iteration based algorithm is proposed for denoising of images based on compressed sensing. This method uses TNN based tuning method for better denoising. The proposed method gives a high PSNR of about 88.06 for a variance of 10^{-4} and 67.55 for a variance of 10^{-1}. It gives a better structural similarity index measure. It is a better algorithm for image reconstruction than existing algorithm. Future exploration could be stretched out to processing of MRI images, hyper spectral images etc. This study investigated the elements that contribute to design and analysis of Savinious rotor blade. In this research work the experimental and computational analysis of Savinious rotor is carried out for rated power output. The blade of wind turbine is designed by using Pro-E software. The structural feasibility is analyzed by Finite Element Analysis method. Finite Element Analysis and the computational fluid dynamics analysis are used in this project. Finite Element Analysis method is used to obtain the maximum deformation and stress experienced by the rotor blade. The computational fluid dynamics analysis is performed in order to obtain the pressure difference between the concave and convex surface of the rotor blade. The force induced to the blade is calculated from aerodynamic analysis. The structure of the Savinious rotor blade is analyzed using ANSYS software and Pro-E Software is used to generate three dimensional model of blade.

REFERENCES

[1] S.C.Bhatia,"Advanced Renewable Energy System"

[2] Lecturer notes "Green Technologies for rural development an overview"

[3] Report on "Renewable Energy Technology Roadmap (Wind,Ocean Wave, In-Stream Tidal & Solar Photovoltaic)

[4] Marco D’Ambrosio, Marco Medaglia "Vertical Axis Wind Turbines:History, Technology and Applications"

[5] NitinTenguria.Mittal.N.D, SirajAhmed.,“Design and Finite Element Analysis of Horizontal Axis Wind Turbine blade” International Journal of Applied Engineering Research, Dindigul Volume 1, No 3, 2010 ISSN 09764259.

[6] Mr. Jesus Vega Fuentes, Mr. Jose M.Carlos “Design of wind turbine blades of a power of 1000 watts for domestic use.” 978-1-61284-1325-5/12, 2012 IEEE.

[7] Mr.V. DíazCasás, Mr.F. Lopez Peña, and Mr.R. J. Duro., “Automatic Design and Optimization of Wind Turbine Blades” International Conference on Computational Intelligence for Modeling Control and Automation, and International Conference on Intelligent Agents, Web Technologies and Internet Commerce 0-7695-2731-0/06,IEEE.

[8] Arvind Singh Rathore et al., “Design and Analysis of Horizontal Axis Wind Turbine Rotor”., International

Journal of Engineering Science and Technology (IJEST)
Vol. 3 No.11 November 2011 ISSN : 0975-5462.