Electricity Generation And Water Pumping Vertical Wind Turbine

Rakshith C[1], Ravi Shankar T S[2], Karthik S[3], Rakesh Sandur[4], Mrs. Nivedita[5]
[1, 2, 3, 4] Dept of Mechanical Engineering
[5] Asst. Professor, Dept of Mechanical Engineering
[1, 2, 3, 4, 5] Nitte Meenakshi Institute of Technology, Bengaluru- 64

Abstract- *This paper emphasis the aerodynamic modeling, analysis of blade and fabrication of VAWT. The main objective of our work is to design a vertical wind turbine having the function of being able to produce electricity and to pump water. Analysis of different blade shape were done and optimal blade design which has a better output capacity were selected. Calculations and results were done and combined. It was concluded that modified savonius type of VAWT can be built at a low budget and can be used for low output application in real life. This project emphasis on electrification of remote areas where load shedding still has to be done to meet with minimum cost and demand of urban areas . Wind turbines are the beginning of a society to reduce damage to land by not using energy sources that produce pollution. It is hoped that the project can enhance research and testing in VAWT frameworks and provides knowledge for different meetings to finalize, in addition, test and improve the productivity and implementation of vertical axial wind turbines. The electricity generated will be stored in a battery and then given to the load and it basically explains the scope of small scale vertical axis wind turbine for home application and for power generation in farming lands.*

Keywords- Blade design, Efficiency, Farming Land, Generation of Electricity, Water pump.

I. INTRODUCTION

Energy in everyday life plays a very important role to carry out any task. The non-renewable resources such as oil, coal and gas are majorly used now a days. Non-renewable energy resources are limited, non sustainable and creates global warming which is hazardous to the environment. Renewable energies are the best way to solve this issue which are available in abundant and sustainable ,inturn can be utilized for requirements. The wind power is the process of producing electricity by the utilization of wind energy through conversion of kinetic energy into mechanical energy in turn to electrical energy. The wind axis machine are classified into two types according to axis of rotation of the rotor. They are horizontal and vertical axis machines.

Horizontal axis turbines has a similar design to a windmill, which has blades that spin on horizontal axis like a propeller having a main shaft rotor and generator top of the tower and pointed towards the wind .Smaller turbines are guided by the wind vane ,whereas the large turbines use a coupled servomotor with a wind sensor. Usage of gearbox, inturn helps the slow rotation into the a quicker rotation which is more suitable for driving an electrical generator.

Vertical wind turbine is type of wind turbine which has the motor shaft running vertically ,with omnidirectional rotation of blade with respect to wind. It has its axis perpendicular to the streamline of the wind and doesn’t require complex mechanism to yaw the rotor and pitch of the blades. The basic types of vawt are darrieus, savonius and giromill, in which each has its specific application of usage.

Savonius Turbine is one of the simplest type of VAWT which is aerodynamically, drag type device having two or more scoops. They require less wind power than other turbines an even the swept area is more enough to give the torque to the blade for efficient output in comparison of other blade design. It is specifically used for the domestic purposes ,farming lands, industrial sites, Rural areas, Street highways etc

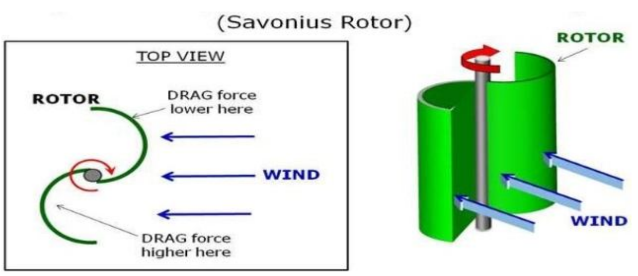

Fig 1 : Savonius blade design

Every savonius wind turbine is characterized by the swept area. The area influences energy output of a turbine ,and the largest it is, the more energy the turbine collects .The air is trapped in the concave part and pushes the turbine. The flow that hits the convex part does produce a drag that is lower than the one on the concave part. It is the differential of the drag force that causes this turbine to rotate. This lowers the efficiency of the turbine as some of the wind's power is used in pushing the convex part.So it has to be modified and designed in such a way that air entrapped should escape out quickly and provide more efficiency of the turbine.

The feasibility of the experiment according the study are amounting to the Fabrication and the required parts that would be used, The estimated amount would be completely cost effective and within the range. The whole project could be easily completed within the stipulated time if the plan of activity is followed religiously. Compact enough to be self-installable and completely eco-friendly. These study makes us to obtain an effective model and construct a efficient blade with high range of performance.

II. METHODOLOGY

A. Design of Different Blades And Its Analysis

1. Modified Savonius Blade : It is a widely used design of blade which is of combination of a drag-driven and lift-driven device, which would have more power co-efficient than other blade design and suitable for small-scale setups and easy installation.

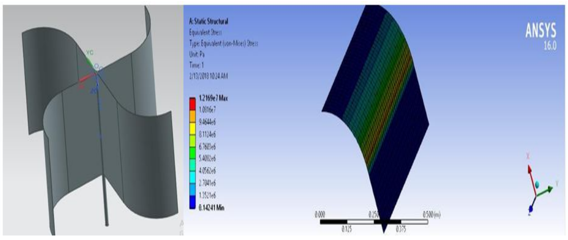

Fig 2 : UG-NX Model and Analysis of Blade

2. Variable Pitch Helical blade :It is one such blade design which adapt and perform optimally for a wide range of wind speeds and turbine rotational speeds, and even allows variable amplitude pitch changes. But the manufacturing and fabrication has complexity and used in large-scale applications.

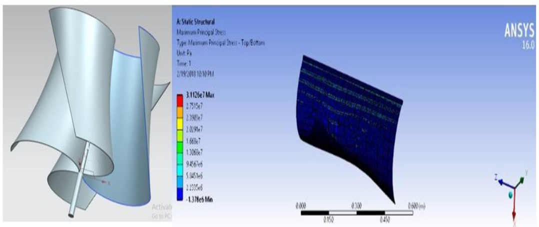

Fig 3 : Helical Blade Design and Analysis

3. Cup-Shaped Blade :It is one such blade design ,which has greater rate of angle of attack and help out to produce more efficiency, but in interns of sustainability and application of torque into the blade it is of weaker design.

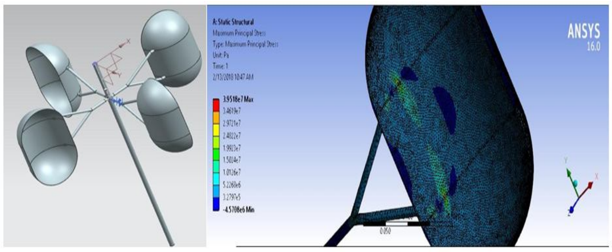

Fig 4 : Cup-shaped design And Analysis

4. Curved-shape Blade : it is one of the vertical blade design which is commonly used for lesser wind speed application sites and usually made up of plastic or polymers and do not sustain more load as the tip speed ratio very less

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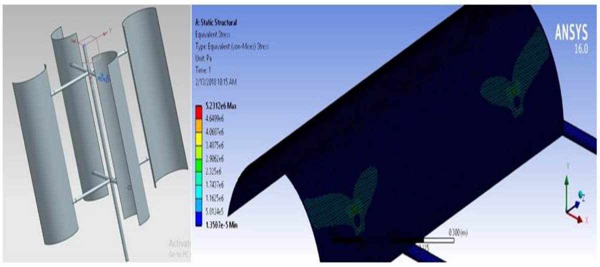


Fig 5 : Curved-shaped Design of the Blade and Analysis

5. Darrieus Blade : A blade design which is capable of producing more efficiency and power output, but includes complication in designing and manufacturing of it, and there chances of failure due to the aero dynamical activity over the blade.

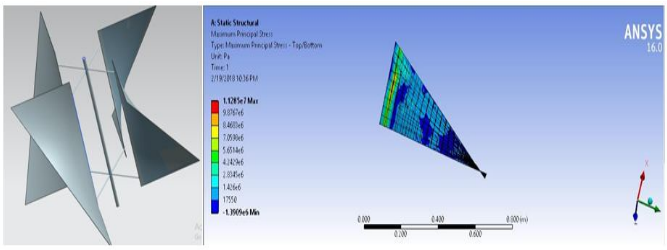
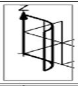
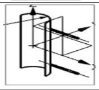
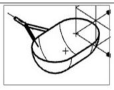
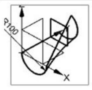
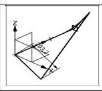


Fig 6 : Darrieus Blade Design and Analysis

B. Comparison Of Different Blades :

The blades were analyzed for different load factors and calculated Von-mises stress and principle stress and was tabulated as shown.

Sl No.	Design of Blade	Force Applied (N)	Stress (MPa)	
			Principle stress(*e6)	Von-mises stress(*e6)
1)		❖ 1 N ❖ 2N ❖ 10N	0.11196 0.22381 1.1177	0.12155 0.2431 1.2169
2)		❖ 1 N ❖ 2N ❖ 10N	4.511 9.0219 14.511	5.2312 10.462 15.511
3)		❖ 1N ❖ 2N ❖ 10N	3.9519 8.104 13.9518	4.8185 9.8956 14.8185
4)		❖ 1N ❖ 2N ❖ 10N	1.0665 2.1331 6.1285	** ** **
5)		❖ 1N ❖ 2N ❖ 10N	3.3992 6.4984 9.1126	** ** **

C. Selection of Suitable Blade Design

The selected blade is more efficient in comparison to other blade design as in the maximum principle stress and von-mises stress is less and apparently suits for our application of usage. It is one such blade design which adapt and perform optimally for a wide range of wind speeds and turbine rotational speeds. It has low angle of attack and high tip speed ratio ,hence it is of omni-directional rotation of the blade over the wind. Design of blade which is of combination of a drag-driven and lift-driven device, which would have more power co-efficient than other blade design and suitable for small-scale setups and easy installation.

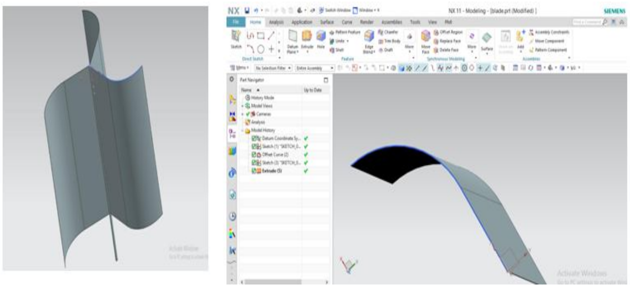


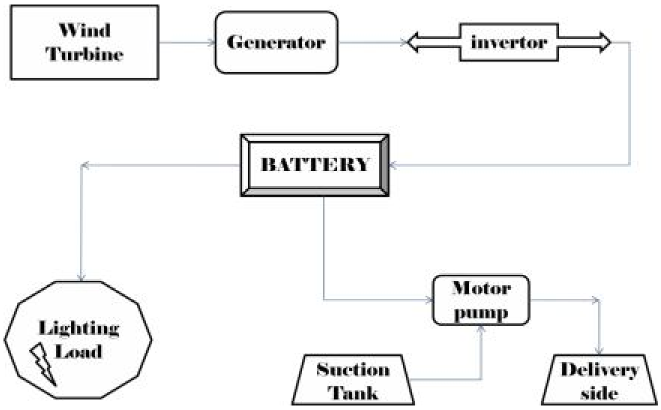
Fig 7 : Selected Blade Model

III. MODEL ASSEMBLY

A Sequential procedure was carried out to accomplish the model with all necessity equipments and materials. Absorbing the knowledge of experimental setup of windmill, a prototype model of vertical wind turbine accordingly to the designed blade which can generate electricity and pump the water was fabricated with all sort of requirements and accomplished in a systematic manner .

Fig 8 : Fabricated Model

Operational Flowchart :



IV. PERFORMANCE PARAMETER CALCULATION AND OBSERVATION

In order to determine the effectiveness of the products that were manufactured, we performed tests to evaluate them. Performance parameters of VAWT is analyzed by testing on different tracks and places and taken down the average values of it.

Theoretical Calculations :

Power= 1/2 ρAV^3Cp watts
ρ= Density of air (1.225 kg/m^3) A = Area m^2 (Pi*r^2)
Tip speed ratio = Blade speed /Wind speed for 3blades(lamda)= 4
Rotor speed (w)=lamda*V/r
Average Wind speed = 5 m/s
Average speed of rotor N2 = 100 rpm
Discharge: Q = A x V
Q = 0.27 X 5 = 1.35 m^2 /min
Input Power P = ½ * p * A * V^3 P =0.5*1.093*0.27*$(5)^3$
P = 18.44 watts

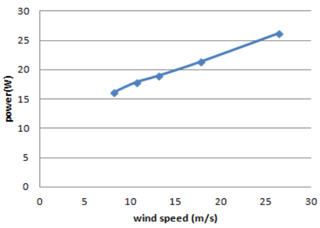
Gear Ratio: N1/N2 =D2/D1 N1/N2 = 30/80 N1/N2 =0.375
Therefore , N1= 0.375*N2
Output Power of Turbine P = 18.44 *0.375
P = 6.916 watts

Observation Table : The below table shows the observed values of power for different wind speed and voltage obtained. It can be notified that as in the wind speed increases the power obtained will be higher and recharge the battery.

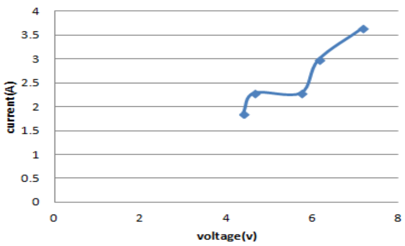
SL No	Speed(m/S)	Voltage(V)	Current(A)	Power(W)
1	6.26	4.39	0.54	2.37
2	6.98	4.64	0.59	2.73
3	7.24	5.73	0.65	3.72
4	8.16	6.14	0.79	4.85
5	9.06	7.16	0.87	6.22

V. GRAPH ANALYSIS

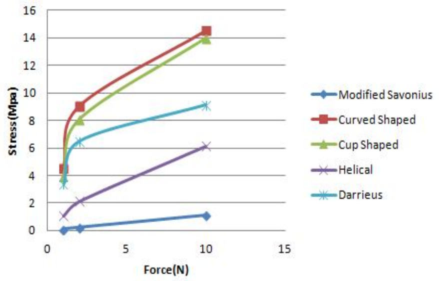
a) **Power v/s Wind speed :** The calculated value of power for different wind speed was tabulated and graph was plotted accordingly. The variation is shown in below graph by which speed increases , even the output power of the generator will increase and it varies for different locations.



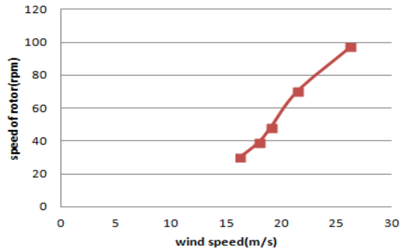
b) **Voltage v/s Current :**The graph shows little variation initially due to the resistance of air along it and after achievement of certain RPM it varies linearly and produce more current.



c) **Principal Stress v/s Force :** The below graph indicates the stress of blades acting upon it for different forces , as in the graph it clearly emphasis that our blade stands in lower stress concentration and have greater thermal efficiency for different environmental aspects.



d) **Rotor speed v/s Wind velocity :**The graphs shows how the speed of rotor decrease with the speed of wind in the initial stages requires torque for the rotation is high and then after certain momentum it will capture the relative wind velocity with less angle of attack.



VI. CONCLUSION

Our work and the results of the supported project are feasible to design and manufacture in a limited time with all the expected results. Vertical axis wind energy conversion systems are practical and far more efficient in terms of efficiency than horizontal wind turbines.

The main theme of our project was to provide electricity and pump water using renewable energy resources and potentially contribute to renewable electricity generation from wind, this project will be useful in rural areas where electricity supply is rare. Inefficient wind speed has been the enormous impact on obtaining the required power, a minimum speed of 15 m / s is required to take into account the acceptable power output. Although we have been able to realize this project of vertical axis wind turbine, there is an endless process to always improve inventions and new designs.

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