Performance Analysis of Vertical Axis Wind Turbine

KSBSVS Sastry[1] V. Sarath Teja[2] Dr. K. Ramesh Reddy[3] BNV Srinivas[4] Krishna Chaitanya Nuli[5]
[1,2,3]Associate Professor [4,5]Assistant Professor
[1,2,3,4,5]Department of Mechanical Engineering
[1,2,3,4,5]Sri Vasavi Engineering College, India

Abstract— The fastest growing renewable energy sector in India is wind energy which is vital for economic growth of the country and since independent India has worked on its resources for increasing its capacity. Keeping this point in view, we thought to fabricate vertical axis wind turbine (VAWT) and analysis the performance in different conditions. In this project we consider two types of blades with two different materials with two different altitudes to assess the the performance and check the condition that gives maximum output. The model made is Savonius type and DC motor is used inversely with Savonius input connected to motor shaft and electrical output taken from the terminals of the motor and this output is utilized to run an application. We also added one solar panel to the turbine to increase the output from the turbine. The main aim of this project is to assess the power output using combination of 2 renewable energy sources with low cost and maintenance. These turbines can be installed on road dividers to utilize wind energy coming from vehicles. The energy produced makes the model a reliable source of continuous energy.

Keywords: VAWT, Savonius, Renewable Energy

I. INTRODUCTION

With population increasing exponentially and our natural resources being strained by increases in demand, it is more important than ever to invest in renewable energy. Our Consumption of fossil fuels as energy has been traced to be a leading cause in Environmental issues. The byproduct of fossil fuel consumption is carbon dioxide, which has been named to be a primary constituent leading to Global Warming. The amount of Carbon dioxide that someone or something produces is known as its “carbon footprint.” The media has been focusing on this issue and many green movements have started to try and reduce our “carbon footprint.” (Green Student U, 2008) here are only a few types of energy that do not produce carbon dioxide. These are Nuclear power and renewable energy sources such as wind, solar and hydro power.

Renewable energy sources are the cleanest from of these sources, because there is no Waste formed as byproducts of these sources. Nuclear energy produces nuclear waste which could take up to but not limited to 100 years until it can be disposed of properly. Wind turbines have been used throughout the world to generate electricity from off shore wind farms to residential smaller scale wind turbines. (California Energy Commission, 2012).

Ferhat Kurtulmus, Ali Vardar and Nazmi Izli have investigated the angle of attacks for 4 various blade profiles, Re Numbers and correlations between lift and drag rates. Snack 2.0, computer software has been used and lift, drag, moment and minimum pressure coefficients are calculated. For all evaluated blade profiles and all Re rates in the provided highest sliding rates most convenient angle of attack was determined in the range of 3o and 9o. The results shown the highest drag rates are found corresponding to Re 20000.

SHEN Zhen-hua, YU Guo-liang, used FFA-W3-211 air foil in the blade model development and conducted a small low speed tunnel and varied the installation angles between 6-14oC and a wind velocity ranges from 8-15 m/s. The results showed that under all conditions the wind 38 power utilization factors of the tested wind turbines are more acceptable when a gurney flap is added.

F. Wang, L. Bai, J. Fletcher, J. Whiteford, D. Cullen, developed a methodology using physical methods including boundary layer theories and wind tunnel experiments and computer modeling using CFD and investigated the wind energy capture improvements at low wind speeds. Optimization of a Scoop design and validation of CFD model. With the final design of scoop boosts the air flow speed and corresponding wind turbine power output. Power curves are developed experimentally and a good agreement was found with CFD model. Scott J Schreck and Michael C. Robinson, examined the full-scale turbine blade aerodynamic blades and current modelling methodologies to better understand the physical and numerical attributes that determined modal performance.

RS Amano, R.J Malloy investigated the possibility of increasing the efficiency of the turbine blades at higher wind speeds while maintaining the efficiency at lower wind speeds by selecting the appropriate orientation and size of the air foil cross sections based on low oncoming wind speed and given constant rotation rate. Swept blade profile was implemented to achieve the efficiency at higher wind speeds. Performance was investigated using CFD. 39 P. Migliore described the results of wind tunnel Aero acoustics tests conducted on a typical small wind turbine blade in the open-jet test section. Tim Fischer studied the influence of the integrated design of the rotor-nacelle-assembly for obtaining the optimizing structure at reduced cost. With an integrated approach, the characteristics and the control of the turbine are used to simultaneously reduce aerodynamic and hydrodynamic loads especially with respect to fatigue.

T K Barlas and G A M Van Kuik, focused on the research regarding active rotor control and smart structures for load reduction. The work is carried with a goal to provide a prospective on current status and future directions of the specific area of research, which includes the specifications of unsteady loads, modern control for load reduction and detailed active aerodynamic control. Feasibility steadies and preliminary performance evaluation and novel computational and experimental research approaches are reviewed. S.M. Habali, I.A. Saleh, have discussed a selection procedure of an air foil section and the aerodynamic design of the blade for a small wind turbine of 5m long. Two different two different air foils mixed at the outer third of the span will be sufficient and demonstrated good strength and aerodynamic characteristics. The results of static proof load test indicated that blade could withstand loads 10 times the normal working thrust, and a field performance test showed that the rotor blade has a 41.2% measured average power coefficient. Dayton A. Griffin carried out a research work to develop cost effective scaling-up of the current commercial blade designs and manufacturing methods. Self-gravity loads, transportation and environmental considerations are the parameters considered. A trade-off study is performed to evaluate the incremental changes in blade cost, weight, stiffness, fabric types and manufacturing processes.

II. FABRICATION OF VERTICAL AXIS WIND TURBINE

Wind energy alone is capable of supplying large amount of power but its presence is highly unpredictable as it depends upon altitude, atmospheric temperature and local conditions. In case of solar energy, the irradiation levels will vary due to sum intensity and unpredictable shadows last by clouds, birds, trees, etc. By combining these two intermittent sources, system power transfer and reliability can be improved significantly.

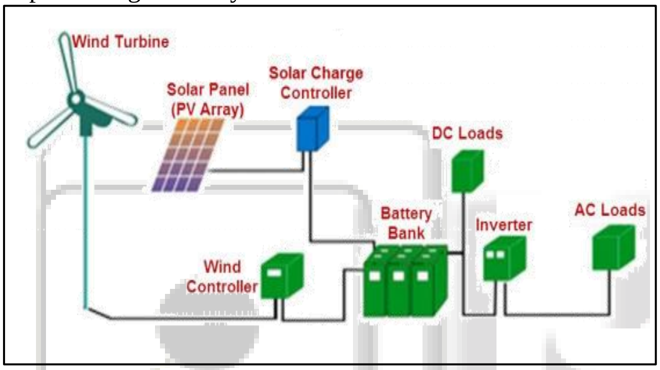


Fig. 1: Hybrid Model

In the above figure dc output from both windmill and the solar panel is first boosted up by the boost converter and given to the battery.

A. *COMPOMENTS REQUIRED*

Cycle rims
- Mild Steel Shafts
- Pvc Pipes
- Pvc Flat Plates
- Bolts
- Solar Cell
- Battery
- Voltage Regulator
- Dynamo
- Stainless Steel Plates
- L-Clamps

1) Cycle rim

Number of components : 2.
Diameter of the rim : 63mm
Width of the rim : 20mm

In this cycle rims are used instead of upper hub and lower hub these rims are connected with shaft and carry the blades. Cycle rims are rotated by the wind power with the help of bearing and transfers the motion through the shaft to generator.

2) Mild steel shafts

Number of components : 3.
Shaft-1 diameter : 55mm
Shaft -1 length : 300mm
Shaft -2 diameter : 50mm
Shaft-2 length : 500mm
Shaft -3 diameter : 35mm
Shaft-3 length : 400mm

3) PVC pipes

Pipe diameter : 127mm
Pipe length : 2500mm

PVC pipes used as the turbine blades. The circular pipes is cut into two parts and the off-section pipe is used as the curved blade.

4) PVC flat plates

Number of plates : 6.
Length of the plate : 400mm
Width of the plate : 5mm

5) Nuts

Number of bolts : 5
Thread diameter : 10mm
Width of the bolt : 20mm

Nuts are used to assembly the parts of the wind mill.

6) Solar cell

a solar cell, or photovoltaic cell, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect, which is a physical and chemical phenomenon. It is a form of photoelectric cell, defined as a device whose electrical characteristics, such as current, voltage, or resistance, vary when exposed to light. Individual solar cell devices can be combined to form modules, otherwise known as solar panels. The common single junction silicon solar cell can produce a maximum open-circuit voltage of approximately 0.5 to 0.6 volts.

7) Dynamo

Specification
Motor output voltage : 5v-24v, turn faster, The voltage is higher.
The maximum load voltage : 40 v.
Maximum output current exceeds : 1500ma
Maximum load power : 20 watts
Weight : 400g

Wind power wind driven dc generator dynamo hydraulic test 6v 12v 24v motor this machine can be used as standby lighting power supply, charging, experiment, teaching, hydroelectric generator...You have a lot of methods to the application. Make small experiment, for small capacity battery, and so on.

III. FABRICATION PROCESS

A. *Base preparation*

- The base is prepared by the concrete foundation.
- The concrete which contains the cement, sand and rock chips
- These mixtures are mixed with water.
- The concrete and water mixed in a ratio of 3:1.
- This mixture is poured in a rectangular mould.

- The centre of the mould placed a circular shaft i.e. shaft-1
- The shaft-1 is one side is welded with the stainless-steel plates.
- This steel plate centre is drilled with diameter of 10mm.
- And onside of the plate is welded with nut.
- The nut and plate centre points must be in same line.
- The plate is welded to the shaft-1, make sure nut welded portion must be Inside the shaft.
- The other side of the shaft is placed in the centre of the concrete mixture.
- After some time, the mixture is strong and it gets the strength to supports the whole frame of the wind turbine

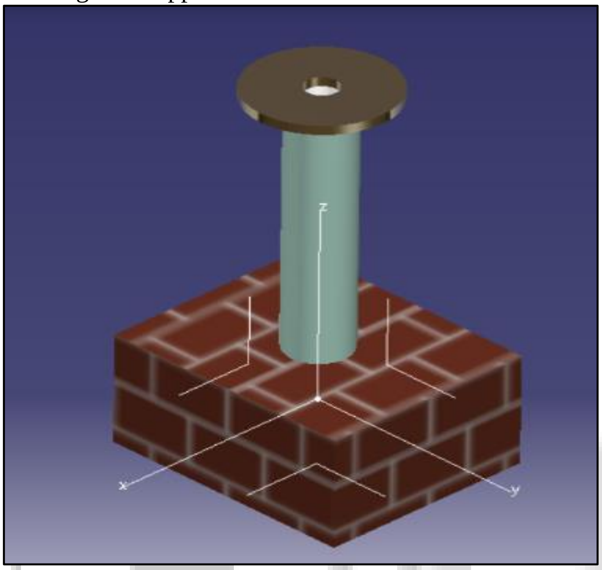


Fig. 2: Base of VAWT

B. Upper and lower hub preparation

- Upper and lower hub preparation is same.in this project instead of hub we use cycle rims.
- Cycle rim with bearing and with centre bolt.
- This cycle rim is welded with L-clamps.in this project we use 12 L-clamps each rim contains six clamps around the rim with equal distances.
- These constructions are worked as the hub, it contains the blades. The blades are attached to the L-clamps.

C. Blade preparation

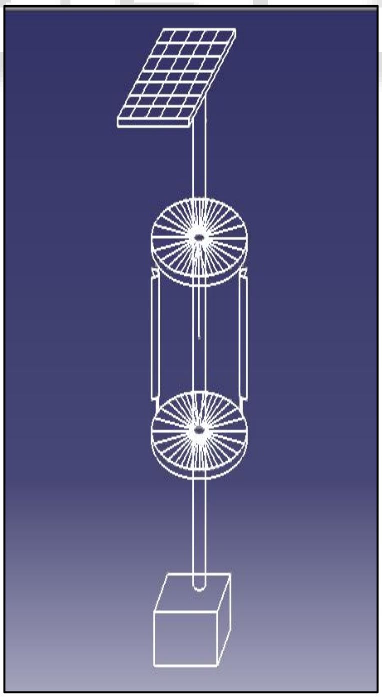
1) Curved blade preparation with PVC

- In this project curved blades are prepared by PVC pipes.
- PVC pipes of above 120mm diameter cut into two parts.
- The half section pipe is used as the curved blade.
- This half pipe is cut into 400mm six equal parts.
- And the same dimensional PVC dummy is taken for the half-curved blades to fill the ends of the pipe.
- The dummy is same cut into two parts, each part is attached at the both ends of the curved sectional pipe with 3mm bolt and nut.
- This part is worked as the curved blades.

2) Curved blade preparation with fibre E-glass fibres

- In this project another type of curved blade is prepared by E-glass fibres.
- In this the curved shape mould is taken i.e. depends on shape of the blade.
- Apply the wax on the mould it helps to remove the blade with mould easily.
- Then apply the E-glass fibre on the wax coated mould.
- Then prepare the mixture of epoxy and hardener in the ratio of 1:1.
- Apply the mixture on E-glass fibre coating.
- Then again apply E-glass fibre on hardener coating.
- Again, apply the hardener on fibre coating.
- Repeats the above procedure up to the required thickness of the blade obtained.
- After the thickness of blade obtained then again apply wax and covered it neatly and place weights on it leave some time for hardening.
- After hardening remove weights and mould the E- glass fibre blade is obtained.

D. Assembling of parts of the VAWT



- The base is rigidly positioned in the required place.
- The main shaft both ends is fixed with cycle rims which contain the L-clamps.
- The L-clamps on bottom side facing main shaft side and top side clamps facing base side opposite to each other.

- This lower rim another side centre bolt is attached to the base shaft i.e. shaft-1 which contain plate with nut.
- And the blades are attached to the upper and lower rim L- clamps. The blades are in between the upper and lower rims. The blades are attached to the L-clamps with 3mm bolt and nut.
- Another side of the upper rim is attached to the shaft -3 with nut welded plate side.
- Other side of the shaft-3 is supporting the solar panels.
- The base shaft bellows the lower rim welded the one L-shaped bar.
- The long end is attached to the base shaft.
- The smaller end supports the dynamo, the dynamo is attached with one-way plugs.
- The lower cycle rim in between two both ends of the cycle rim covered with rubber tube, it acts as the ropeway. The rubber tube helps to reduce the friction due to ropes.
- The dynamo shaft and main shaft is connected through cycle rope way with rope.
- And the dynamo converts mechanical energy into electrical energy the out from the dynamo which is electrical energy is saved on battery which is connected to the dynamo.
- The battery also receives electrical energy from solar panels.
- The battery is connected to the any electrical applications

IV. CONCLUSIONS

In the present work, we considered two types of blades (i.e. curved and flat blades) with two different materials and placement of turbine at two different heights with a solar panel. With and without adding solar panel, the turbine was examined for power generation in constant period of time and based on the power output obtained; we conclude that the turbine with curved blades installed above the ground level with the addition of solar panel gives the maximum output. From the results we conclude that this type of design is the best from the other designs considered in the present study. The turbine output was more when it was placed on a road divider where there was heavy traffic. We conclude that the curved blades are best over the flat blades. The curved blade holds the wind in the curves and absorbs the maximum wind intensity than flat blades. In case of curved blades, the wind enters into the curved portion escapes slowly but in flat blades the wind escapes easily & so the efficiency of the blades also reduces. Considering the material of the blades, we can conclude that PVC gives better performance over epoxy because of property differences.

We conclude that the wind mill with solar panel gives more output. By adding more panels, we can increase the power output. If wind power is less, power from solar panels act as substitute and vice versa. This type hybrid turbines would develop substantial amount of power in a given situation and gives effective results due to the combination of solar and wind energies. We conclude that this type of hybrid turbine has more advantages, useful and works with high efficiency.

REFERENCES

[1] Saha, U. K., S. Thotla, and D. Maity. "Optimum design configuration of Savonius rotor through wind tunnel experiments." Journal of Wind Engineering and Industrial Aerodynamics 96.8 (2008): 1359-

[2] F.L. Ponta, J.J. Seminara, A.D. Otero On the aerodynamics of variable-geometry oval-trajectory Darrieus wind turbines Renewable Energy, 32 (2007).

[3] J.D.K. Bishop, G.A.J. Amaratunga Evaluation of small wind turbines in distributed arrangement as sustainable wind energy option Energy Conversion and Management, 49 (2008), pp. 1652–1661.

[4] M.H. Mohamed, G. Janiga, E. Pap, D. Thévenin Optimal blade shape of a modified Savonius turbine using an obstacle shielding the returning blade Energy Conversion and Management, 52 (2011)

[5] Rehan Jamil, Zahid Hussain, Vertical axis wind turbine A review of various configurations and design techniques, Renewable and Sustainable Energy Reviews, Volume 16, Issue 4, May 2012

[6] Tetsuya Wakui, Ryohei Yokoyama, Wind speed sensor less performance monitoring based on operating behavior for stand-alone vertical axis wind turbine, Renewable Energy, May 2013

[7] Daegyoum Kim, Morteza Gharib, Efficiency improvement of straight-bladed vertical-axis wind turbines with an upstream deflector, Journal of Wind Engineering and Industrial Aerodynamics, Volume 115, April 2013

[8] Islam Abohela, Neveen Hamza, Steven Dudek, Effect of roof shape, wind direction, building height and urban configuration on the energy yield and positioning of roof mounted wind turbines, Renewable Energy, Volume 50, February 2013.

[9] Rao, Singiresu S., and Fook Fah Yap. Mechanical vibrations. Vol. 4. Reading, MA: Addison Wesley, 1995.

[10] Jureczko, M. E. Z. Y. K., M. Pawlak, and A. Mężyk. "Optimisation of wind turbine blades." Journal of Materials Processing Technology 167.2 (2005): 463-47.

[11] Lu, Lin, Hongxing Yang, and John Burnett. "Investigation on wind power potential on Hong Kong islands—an analysis of wind power and wind turbine characteristics." Renewable Energy 27.1 (2002): 1-12.

[12] Non-Conventional Energy / Ashok V Desai /New Age International (P) Ltd

