

# Design and Analysis of Vertical Axis Wind Turbine

Nabin sapkota<sup>1</sup>, Ranjan kumar sapkota<sup>2</sup>

<sup>1</sup>Student, Mechanical Engineering, Uttarakhand Technical University, India

<sup>2</sup>Student, Electrical and Electronics Engineering, Uttarakhand Technical University, India

\*\*\*

**Abstract:** With the current surge in fossil fuels prices, needs for cleaner electricity sources, and authorities funding incentives, wind generators have come to be a plausible science for electricity generation. Currently, horizontal axis wind generators (HAWT) is dominating the market by its giant size and high power generation. However, vertical axis wind turbines (VAWT) are capable of producing a lot of power, and offer many advantages over (HAWT). The most important goal of this project is to design, analyze and fabricate vertical axis wind turbine to operate in low wind velocity condition.

Parametric studies are performed by using the software SOLIDWORKS and Stress analysis, vibration analysis and other various analysis is done using CFD. We conclude from the research that the mass moment of inertia is the most dominant sketch parameter when you design wind turbine to work in low wind velocity conditions. PVC pipes are the most affordable and cheap material for making the aero foils at the rural areas for small wind turbines.

**Keyword:** fabrication, efficiency, power generation, vertical axis wind turbine.

## 1. INTRODUCTION

Energy is a hot gossip in the news today: increased consumption, increased cost, depleted natural resources, our dependence on foreign sources, and the impact on the environment and the natural resources. Something has to change in order to cope up with the probable shortage of alternate of energy. It can be termed as the green energy as it does not cause any harm to the nature and the natural resources. It is very reliable and affordable to the people living in the remote areas. [1]

Wind energy has become one of the best option to lessen our dependence on traditional resources like oil, gas and coal and to do it without as much damage to the environment. Alternative energy Sources, also called renewable resources, deliver power with minimal impact on the environment. These sources are typically more green/clean than traditional methods such as oil or coal. In addition, alternative resources are inexhaustible. Vertical-axis wind turbines (or VAWTs) have the main rotor shaft arranged vertically. [3] One advantage of this arrangement is that the turbine does not need to be pointed into the wind to be effective, which is an advantage on a site where the wind direction is highly variable, for example when the turbine is integrated into a building. Also, the dynamo and the gearbox can be placed in the lower portion of the turbine and it does not need great height to generate electricity. [2] The advantages of vertical axis wind turbine are as follows:

1. It is independent to the direction of the air flow.
2. It produces less noise
3. It is very compact
4. It is very cheap

## II. LITERATURE REVIEW

Wind turbines operate on a simple mechanism. The wind energy turns the blades around a rotor. The rotor is connected to the main shaft, which rotates a dynamo to generate electricity. A wind turbine used for charging batteries may be referred to a wind charger.

Millions of wind turbines are installed around the world to generate alternate source of energy, these turbines may be horizontal or vertical. [1] The small turbines can be used as the source of energy for small boats, traffic signals as well as in the automobiles as the additional source of energy. Medium sized turbines can be used for making small contributions to a domestic power supply while selling unused power back to the utility supplier via the electrical grid. Large turbines, known as wind farming are used by many countries around the globe to reduce their dependence on fossil fuels. And this concept will be very fruitful to the country like India to reduce the consumption of coal and petroleum products. The major cities of India are being extensively polluted due to the excess use of coal and petroleum products. So, this project can be the best possible choice. [4]

So how do wind turbines make electricity? Simply stated, a wind turbine works the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. The wind turns the blades, which spin a shaft, which connects to a generator and makes electricity.

## III. DESIGN OF THE WIND TURBINE

The initial stage of the project involves software analysis of the proposed designs. We use SOLIDWORKS software for the simulation and modeling. CFD (Computational Fluid Dynamics) is also used for its further analysis. Initially the measurements of various components are collected, and then we begin designing procedure.

**1. Design consideration:**

**Economic consideration:** the project should be available at the minimal cost so that it can be affordable to each and every individual.

**Material selection:** the materials should be selected properly as it is placed upon high air pressure. The material should be robust and light in weight. Here we use PVC (Poly vinyl chloride) pipe as the blades and wrought iron as the frame and base. Various parameters used are as follows:

1. Blade profile: radius=41mm, thickness=3mm, length=297mm
2. Rotating frame: dimension (53\*25\*25) mm
3. Shock absorber: dimension (53\*25\*4) mm

**2 design approach**

The development of the design is carried out using the above mentioned parameters. The flow simulation is show below:

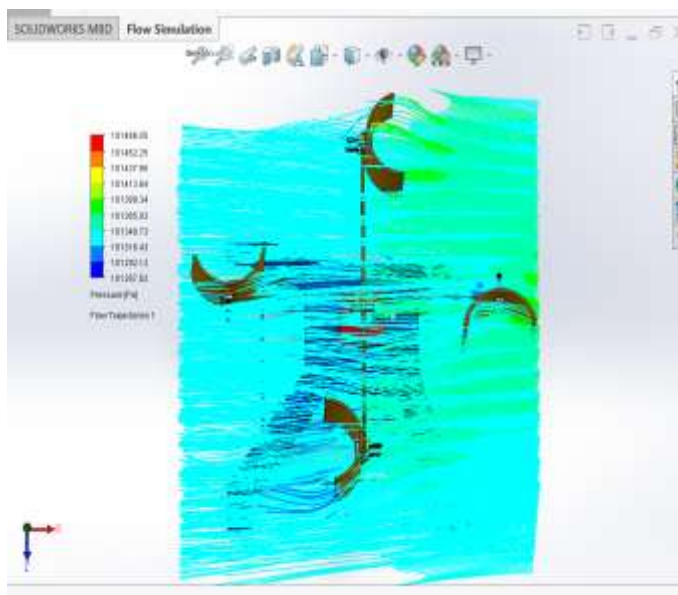


Fig1. Flow simulation at velocity 10m/s

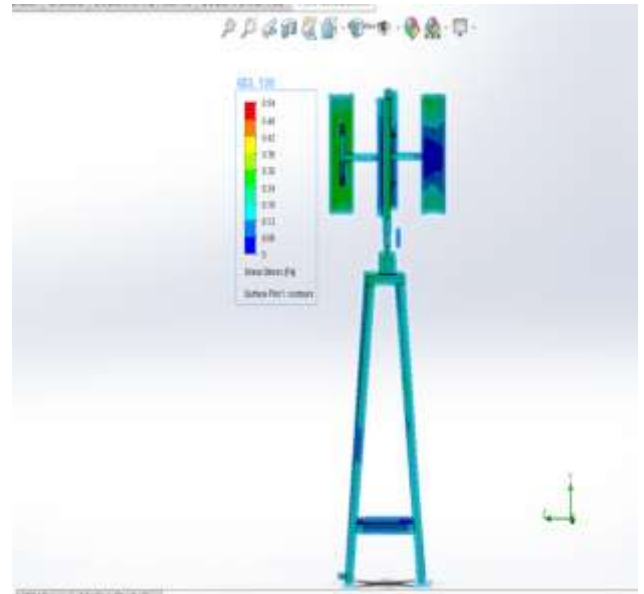


Fig.2. shear stress variation throughout the system

Table 1. Value of force and pressure at velocities 1-10 m/s

S.N	Velocity(m/s)	Avg. static pressure(pa)	Avg. normal force(N)
1	1m/s	101325.5	0.076
2	2m/s	101327.2	0.273
3	3m/s	101329.9	0.623
4	4m/s	101333.9	1.166
5	5m/s	101338.5	1.975
6	6m/s	101346.5	2.26
7	7m/s	101352.2	3.749
8	8m/s	101363.2	4.015
9	9m/s	101369.8	5.94
10	10m/s	101380.6	8.478

The values of force and pressure mentioned above in the table are the simulated values using CFD. The values of the force and pressure are plotted in the graph to represent the changing behavior of the turbine along with the change in the velocity of air. Here the velocity of air changes from (0-10) m/s.

These values are represented in a graph as velocity vs. force, velocity vs. pressure and pressure vs. force.

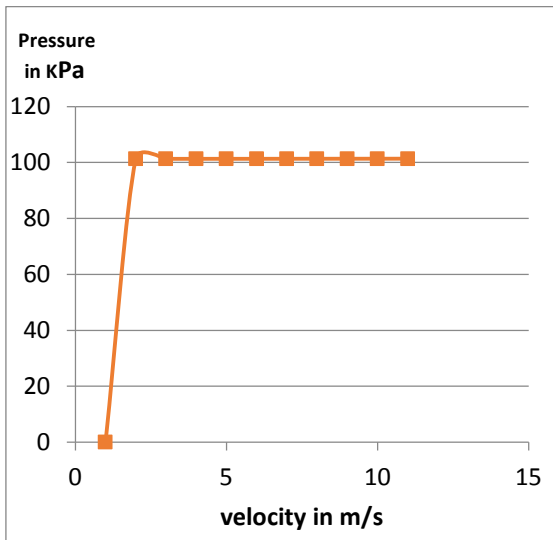


Fig.3. pressure vs. velocity

The graph of force vs. velocity is as follows:

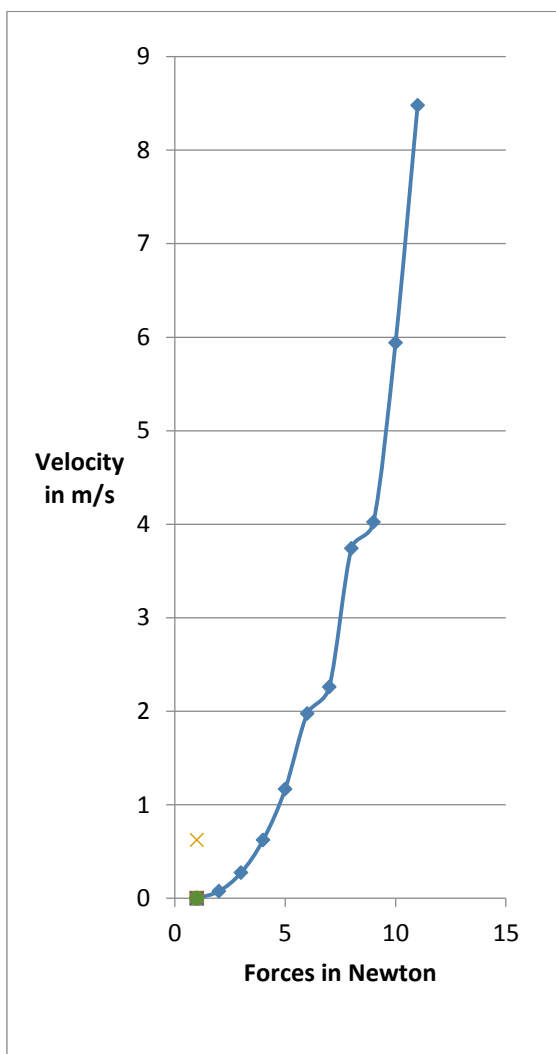


Fig. 4. Force vs. velocity graph

#### IV. Fabrication

The designed wind turbine is fabricated in the college workshop with the available tools and materials. The procedure are as follows:

1. Marking on the material of the blade and the frame
2. Cutting of the segments
3. Drilling of the holes, fitting of the nut and bolts on the blade.
4. The welding of the frame and the support
5. Placement of the generator (6volt) and the electric voltage regulator

The figure below represents the blade, base and the complete setup.



Fig.5. blade

After making the turbine blades, we assemble these blades to the main rotating shaft as per the design. We directly mount the dynamo and the rotating shaft by using a nut. Rotating frame is made up of the wrought iron and the dimension of main rotating shaft is (190\*25\*25) mm.



Fig.6. rotating shaft

After the fabrication of the rotating part, we fabricated the support of the wind turbine .it has four legs .we fabricated this support so that stress distribution will be very low.



Fig.7. support system

## V. TESTING

We setup a test using a wind speed of 7m/s which is measured using an anemometer. We inspect the output obtained from with the help of multimeter. For an average wind speed of 7 m/s the maximum voltage is 0.2 V and maximum current is 80 mA.

## VII. CONCLUSION

The blade profile are tested on CFD and their various parameters like stress, force, static and dynamic pressure and friction coefficient are calculated. The blade profile of radius 41mm, thickness 3mm and the length 297mm develops high drag force. This implies that the torque will be maximum at the lower velocities of air. The material PVC is used because of its strength, lightweight, minimum deformation and affordable price as compared to other materials. The simulated design is successfully fabricated and tested. The output voltage and current are measured by the multimeter present in the electrical laboratory.

## REFERENCES

- [1]. Dr. Hettiarachchi N.K., Jayathilake R.M., Sanath J.A. "Performance Simulation of a Small Scale Vertical Axis Wind Turbine (VAWT) with the Integration of a Wind Deflector System", Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, University of Ruhuna, Mar 19, 2014
- [2]Hau E 2005 Wind Turbines (Berlin: Springer)
- [3] Schubel P.J. and Crossley J., Wind Turbine Blade Design, Energies, 2012, 5(9), pp. 3425-3449.
- [4] ] Bhadang S.J. and Kale B.N. Design, analysis and power generation through vertical axis wind turbine, Indian Streams Research Journal, 2015, 5(9), pp. 1-17.
- [5] Ali M.H., Experimental comparison study for Savonius Wind Turbine of two and three blades, International Journal of Modern Engineering Research, 2013, 3(5), pp. 2978-2986.
- [6] Hill N, Dominy R, Ingram G and Dominy J 2009 Proc. IMechE Part A: J. Power and Energy **223** 21-29
- [7] Gundtoft S 2009 Wind Turbines (Aarhus: University College of Aarhus)