Analysis and Design of Darrieus Helical Wind Turbine

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Abstract – *This paper is about creating a Design of Vertical Axis Wind Turbine and testing its performance. Throughout the course of the study, it is proven that the vertical axis wind turbine is much more efficient than its predecessors due to the nature of its grasping wind, and harnessing its energy. The main objective of this project is to use vertical axis wind turbine in day to day life. a vertical axis wind turbine is cheaper than horizontal axis wind turbines. Although HAWT is more efficient at converting wind energy into electrical energy but small VAWT is more suited to an urban area. Because they have low noise production and low vibration create on a structure. Also using Darrius type turbine over Savonious type turbine for more suitable applications. Using DU 06 W-200 dt blade shape design for a high tip speed ratio. Darrius turbine gives us the benefit of the wind's drag and lifts force.*

Key Words: Darrieus turbine, Small VAWT design, Gorlov turbine

1. INTRODUCTION

Conventional sources of power have become very expensive. So, we decide to do a project on renewable energy sources that are available in urban areas like wind energy, and from that how can we produce electricity so one needs can be satisfied and also direct installation near consumer so energy loss and transportation charge also reduce. we are going to design and perform some analysis on a helical wind turbine that can install on more than one site. The paper will consist of a design data of helical vertical axis wind turbine's different components that we can implement in an urban area.

1.1 Brief History of Vertical axis wind turbine

A wind turbine is followed to make use of wind power and its ability to make employing the air flows that occur naturally in the earth's atmosphere. Wind turbines were set on as windmills first whose blades capture this kinetic energy from the wind and turn it into mechanical energy, spinning shafts that moved the lever of pocket. Windmills had only a main drawback which was the seasonality of the wind. Devices of this kind, which had not been used since the early Middle Ages, found a new application after the Finnish engineer S.J. Savonius invented a new type of rotor in 1922. Known as the Savonius rotor, it consists of semicircular blades that can be constructed from little more than the two sections of an oil drum, cut in half along its vertical axis, and welded together with an offset from the axis to form an open S. An advanced version of this machine installed at Manhattan, Kan., during the 1970s generated several kilowatts of electric power in a 12-meter per-secondwind.

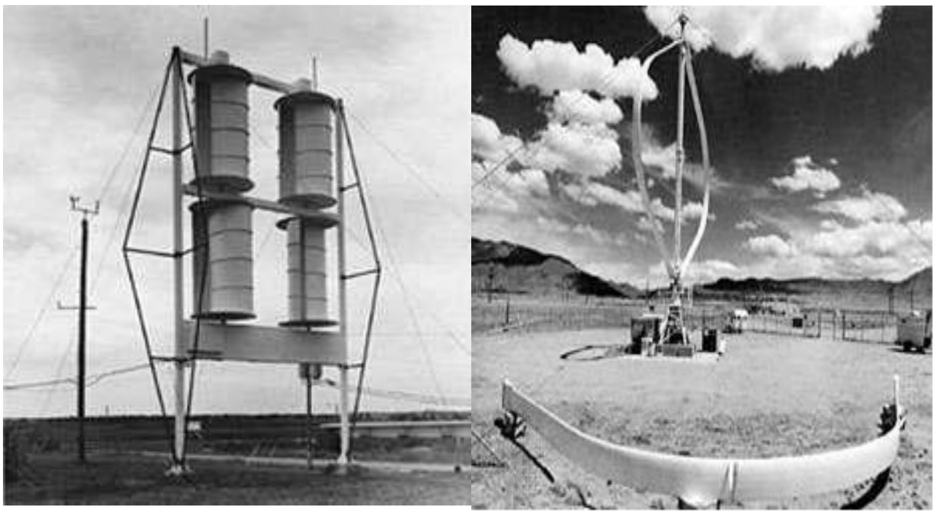


FIG-1: Savonius rotor design by S.J savonius in 1992 & Egg shape darrieus turbine

The most recent vertical wind turbine is based on a machine patented in 1931 by the French engineer G.J.M. Darrieus. Its two blades consist of twisted metal strips tied to the shaft at the top and bottom and bowed out in the middle similar to the blades on a food mixer. A Darrieus turbine with aluminium blades erected in 1980 by the Sandia National Laboratories in New Mexico produced 60 kilowatts in a wind blowing 12.5 meters per second. Turbines of this variety are not self-starting and require an external motor for a start-up. Several models of Darrieus turbines have been built since the construction of the Sandia unit.

There are two types of vertical axis wind turbines Darrius wind turbine is drag and lift type wind turbine and savonius wind turbine is only dragged type wind turbine.so savonius wind turbine is rotating at less speed than wind speed. So, this turbine is not applicable to power generation. And Darrius turbine blade rotates at a higher speed than wind speed.
Also, in the savonius turbine due to drag force more vibration created. And due to balance shape design, there is no vibration occurs in the darrieus turbine's body.

1.2 Development of wind turbines over the years

The emergence and evolution of wind-driven devices for electric power generation are briefly surveyed here. For the origin and development of the traditional windmill and other predecessors of modern wind turbines, see energy conversion. The development of the electric generator aroused some interest in the wind as a "free" power source. The first windmill to drive a generator was built in 1890 by P. LaCour in Denmark, using patent sails and twin fantails on a steel tower. Adopting the ideas gained from airfoil and aircraft propeller designs, windmill designers and manufacturers began to replace broad windmill sails with a few slender propeller-like blades. In 1931 the first propeller wind turbine was erected in Crimea. From the 1940s, experimental twin-blade turbines were constructed in the United States and later in Scotland and France. In the Netherlands, a few old-fashioned mills were adapted to generate electricity. Today, wind turbines for electric power generation are the most commonly propeller-type machines.

2. LITERATURE SURVEY

The idea for Vertical Axis Wind Turbines (VAWTs) has been blowing around for decades, but despite many advantages, the technology has so far attracted little interest. This literature is about how darrieus wind turbine works and where we can use it for different serving purposes.

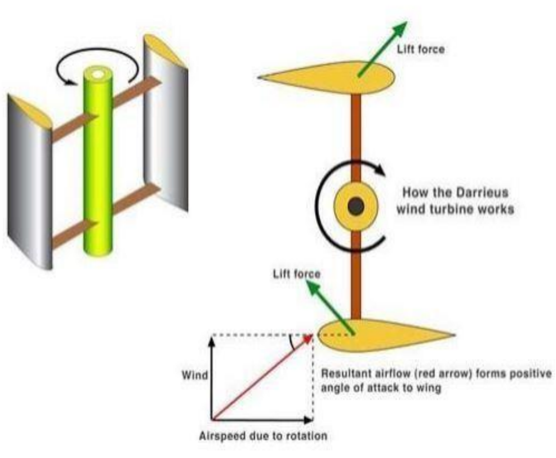


Fig-2: Aerodynamics on VAWT

The resultant of the wind speed and the airspeed due to rotation forms a positive angle of attack of the lift force to the wing. The red line in the above picture shows the positive angle of attack.

A Darrieus turbine becomes unstable above a certain height. The largest Horizontal Axis Wind Turbines (HAWTs) are capable of producing 6 MW of power and stand just short of 100 meters tall, but if made any bigger they start to become less efficient. One reason is that the weight of the turbine blades becomes prohibitive. As they turn, this places the blades under enormous stress because gravity compresses them as they rise and stretch them as they fall. The larger you make these structures, the more robust they must be in order to withstand these forces. In addition, the cost and difficulty of building the increasingly large towers needed to keep this top-heavy structure stable lead to a major engineering challenge. An advantage of VAWTs is that they can catch the wind from all directions eliminating the need for a yaw mechanism.

In addition, they can be built lower, so they are less visible and can withstand much harsher environments and do not need to be shut down when wind speeds exceed 64 mph, and even then the structures are claimed to withstand speeds of up to 110 mph.

Their use on military bases is contemplated because they are shorter and interfere less with helicopter operations and with radar. Vertical-axis wind turbines are less efficient than horizontal axis wind turbines since half of the time the blades are actually moving against the wind, rather than generating the lift needed to spin an electrical generator. As the blades alternatively catch the wind and then move against it, they create wear and tear on the structure. Adding half a shield against the return stroke would solve the problem.

This report describes the wind power and its potential that can be harnessed in the future to meet the current energy demand. With a detailed description of the wind turbine and the wind, the generator focus has been given on the interconnection of the generators with the grid and the problems associated with it. The shape of the blades is changed to helical so that it can rotate continuously in any direction of the wind. Hence the efficiency of the turbine is improved and also the stresses are minimized. Conclusions were made about the behaviour of the wind in urban locations. Thereafter, the helix angle of the blade is changed and the best angle of operation is analyzed.

- Tip Speed Ratio The tip speed ratio is very important. The tip speed ratio (λ) for wind turbines is the ratio between the rotational speed of the tip of a blade and the actual velocity of the wind.
- The tip speed ratio is directly proportional to the windmill's productivity. High-efficiency 3blade-turbines have a tip speed of 6 to 7.
- Betz Limit No wind turbine could convert more than 59.3% of the kinetic energy of the wind into mechanical energy turning a rotor. This is known as the Betz Limit and is the theoretical maximum coefficient of power for any wind turbine. The maximum value of Cp according to the Betz limit is 59.3%. For good turbines, it is in the range of 35 – 45%.
- The material used in Wind Turbine Blades The latest blade design is made of fiber-glass and epoxy resin. Its unique feature is its curvature like tip which allows it to catch low wind speeds. The turbine blades made of carbon fiber are lightweight and have a razor-sharp edge which allows it to literally cut through the wind and makes it almost silent. The material of the blade is glass fiber - epoxy resin. It is less expensive than carbon composite. Fiberglass composites are insulators, which means they do not respond to an electric field and resist the flow of electric charge, insulators, which means they do not respond to an electric field and resist the flow of electric charge.

In recent years more focus is put on the applications of wind turbines in the urban environment. One of the ways to do this is by using a turbine with a vertical axis (a VAWT). This type of wind turbines is around for many centuries. The modern equivalent which is based on lift producing blades only exists for 30 years. In this period airfoils for this application have been developed, but still, much work can be done in this field.

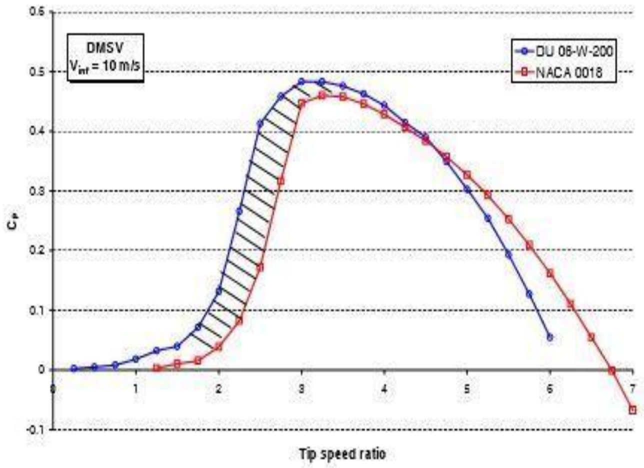


Fig-3: Tip speed ratio

3. DESIGN CONSTRAIN

- Engineering-wise, this project requires a lot of parameters to be taken into account, because the helical turbine design has numerous variables that need to be optimized, such as the blade profile, chord length, height, radius of the turbine material of the blade.
- The design should be created that way so the turbine can operate at low wind speed also.
- Wind come from all the direction and helical turbine blade's design puts lots of cyclic load over the blade, thus not all materials are suitable for blade design. Metallic design is not compatible with these loads so the best choice of material is a composite material. Because they are suited for this design as they are less prone to fatigue caused by cyclic stress.
- The application of these projects to implement the model in rural is on street poles, road dividers, on any building's terrace, on the garden, and at the seashore where we can get continuous wind supply. So the turbine can develop power for general use. Well, it is obvious that the size should be small that it can fit in small are and it should be economical so everyone can afford it. So, to reduce the cost of the turbine more economic material should be used.
- Well, it cannot create any disturbance in daily life like create continuous whirling sound, mechanical failure. So by using fewer mechanical components, we can reduce maintenance, using a permanent magnet generator in order to eliminate the use of gearboxes.
- The turbine required an open area, preferably on a high mounting point in order for the wind to have a sufficient amount of velocity to spool the blade. And for that the support body design in that way so it can fit the turbine and wall mount itself also absorb the vibration created by the rotating blade.

3.1 Turbine sizing and estimation of power

In general, the environmental parameters, or the parameters governed by the flow field in which the turbine is to be placed, are fixed and the designer has little option to change any of them in an attempt to increase efficiency. These parameters include important values such as the free stream velocity and the density of the air.

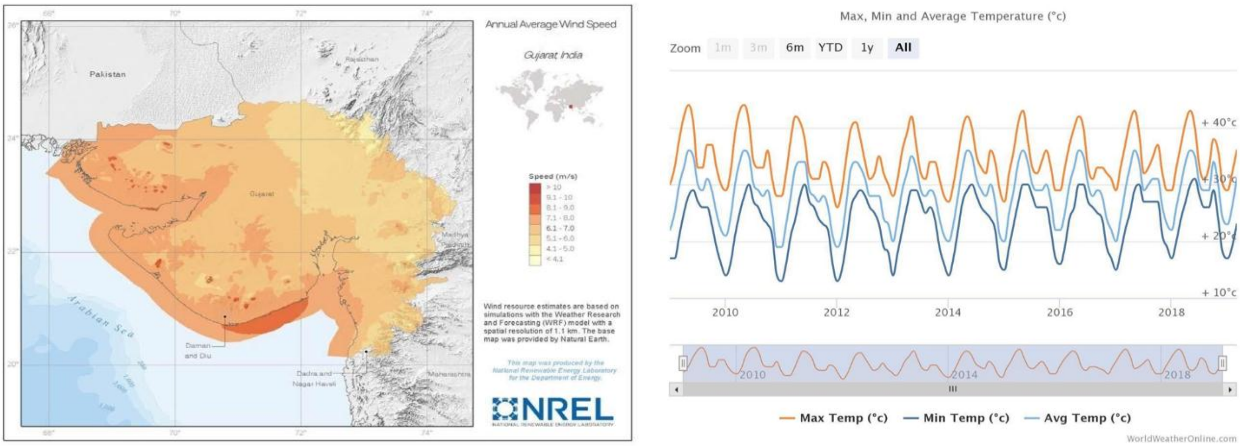


Fig-4: Average yearly wind speed and Temp. in Gujarat

From the National Renewable Energy Laboratory's (NREL) the average wind speed during a year in Gujarat is 7m/s. and from the figure we can take the average temperature in Gujrat is 30°C.
For the calculation of air density, we use equation,

$$\rho = \frac{P}{R \times t}$$, Where:

P = 101325 pa
R = gas constant 287.05 J/kg K
t = 30+273=303 K

so,

$$\rho = \frac{101325}{287.05 \times 303} = 1.164\ kg/m^3$$

So, we get the air density 1.164 kg/m^3

- The turbine is going to fit in a small space area so size should be optimal therefore we choose the dimension of the turbine within 1 meter. We perform a design study in Solidworks we choose the parameter of height 500,1000,1500 mm and diameter 350,700,1050 mm. we put constrain that factor of safety is greater than 1 and stress would be minimized. After performing we get optimal result in height 1000 mm and diameter 700 mm with stress 90.625 N/mm^2 and fos is 1.37929
- Then we calculate the power output of the turbine. So, we can get an idea about what can we get from the original turbine.
  Here are some parameters,
- λ: Tip speed ratio
- r: Turbine radius
- ▯: Angular velocity
- ▯: Average air velocity
- ▯ =0.7/ 2= 0.35 ▯
- Let wind speed from average result data, ▯ = 7 ▯/s

$$\lambda\text{average} = \frac{2.5+2}{2} = 2.25$$

$$\omega = \frac{\lambda \times v}{r} = \frac{2.25 \times 7}{0.35} = 45 rad/s$$

Thus,

$$T = \frac{(0.5 * C_P * \rho * A * V^3)}{\omega}$$

Where A= $l \times d = 1 \times 0.7 = 0.7m^2$

By putting this value, we get torque T=1.707 Nm

$$p_{flow} = 0.5 \times \rho \times A \times V^3$$
$$= 0.5 \times 1.164 \times 0.7 \times 7^3$$
$$= 139.73 \text{ W}$$
$$P_{turbine} = p_{flow} \times c_p$$
$$= 139.73 \times .55$$
$$= 76.85 \text{ W}$$

So, the theoretical power output can be at different wind speed is,

Table-1: Theoretical power generation

Wind speed (m/s)	Wind speed (km/hr)	Power generation(W)
4	14.4	14.3
6	21.6	48.39
7	25.2	76.85
8	28.8	114.72
10	36	224.07
12	43.2	387.19
14	50.4	614.84
16	57.6	917.79

3.2 Blade Design

We analyzed many works of literature and find that for 3 blade turbines and for higher output DU 06 W 200 profile blade is best so we decide to use this blade.

A turbine with high solidity allows keeping the optimized turbine rotational velocity relatively low, which minimizes the rotor vibrations and maximizes the aerodynamic efficiency.

- For accurate manufacturing and efficient design, we decide to make a blade from 3d printing technology. for printing material, we have various options like ABS, ABS PC, PLA, And PLA+. We decide to make a blade from PLA+ material because it is strongest of all 3d printing material.
- These are the properties of PLA+ material.

Table-2: PLA+ Material properties

S no.	Property	Value
1	**Technical name**	**Polylactic acid plus(PLA+)**
2	**Chemical formula**	$C_3H_4O_2$
3	**Tensile strength**	**70 Mpa**
4	**Printing temperature**	**205-225 ℃**
5	**Density**	**1240 kg/m^3**
6	**Elastic modulus**	**2.41 Gpa**
7	**Poisson's ratio**	**0.3897**
8	**Shear modulus**	**0.86 Gpa**
9	**Yield strength**	**101 Mpa**

The solidity was chosen to be high, at around 0.15, the solidity then can be calculated using the equation:

$$\sigma = \frac{B \times C}{\pi \times d}$$

Where:

σ: The solidity =0.15 (from research papers)

B: Number of blades

C: Chord length

d: Diameter of the turbine

Rearranging equation: $c = \frac{\sigma \times \pi \times d}{B}$

$$c = \frac{0.15 \times 3.14 \times 0.7}{3} = 110\ mm$$

Using wind speed 7 m/s and density of air are 1.164 kg/ m^3. Blade surface area 0.23625234mm^2 and the dynamic pressure is 29.06 pa which is wind load on a blade these values we get from Solidworks.

$$wind\ load = dynamic\ pressure \times blade\ are$$
$$= 29.06 \times 0.23625234$$
$$= 6.86\ \text{N}$$

Fig-5: Dynamic pressure at different wind speed (N/$\boldsymbol{mm^2}$)

Fig-6: Blade manufacturing

3.3 Shaft Design

- The shaft is subjected to two forces and torque, the torque resulting from the rotation of the blades due to wind orthogonal to the shaft; the torque is previously calculated and was found to be equal to 1.707 □.□, the wind load calculated which is equal to 6.86 □, and the turbine weight which is obtained through SolidWorks, was found to be 104.48 □.
- The shaft is a rotating element of the turbine so it has to lightweight. So, aluminium alloy 1060 H-18 is best and easily available in the market.

the stress formula is

- $\sigma_x = \frac{P_w}{A}$

Where:

P_w: Wind load on the blade

□: Cross-section area of the shaft

- $A = \frac{\pi d^2}{4}$

□ =diameter of shaft 0.025 □

- □ = $\frac{\pi \times .025 * .025}{4}$=0.005$m^2$

Therefore $\sigma_x = \frac{6.86}{0.0005}$ =13.72 kPa

And

- $\sigma_y = \frac{W}{A}$

Where:

□: Weight of the turbine, □: Cross-section area of the shaft

Therefore: $\sigma_y = \frac{104.48}{0.0005}$=296.96 kPa

The torsion in the shaft can be calculated by:

$\tau = \frac{T \times r}{j}$

Where, T: The torque

r: Radius of the shaft

J: Polar moment of inertia which can be found using the equation:

- □ = $\frac{\pi}{2} \times r^4 = \frac{\pi}{2} \times (0.0125)^4 = 3.83 \times 10^{-8} m^4$
-

Then the torsion becomes:

$$\tau = \frac{1.707 \times .0125}{3.83 \times 10^{-8}} = 0.557\ MPa$$

The principal stresses than can be calculated using the equation:

$$\sigma_1, \sigma_2 = \left(\frac{\sigma_x+\sigma_y}{2}\right) \pm \sqrt{\left(\frac{\sigma_x-\sigma_y}{2}\right)^2 + \tau^2}$$

- $\sigma_1 = \left(\frac{13.72+296.96}{2}\right) + \sqrt{\left(\frac{13.72-296.96}{2}\right)^2 + 557^2}$

  = 730.055 kPa
- $\sigma_2 = \left(\frac{13.72+296.96}{2}\right) - \sqrt{\left(\frac{13.72-296.96}{2}\right)^2 + 557^2}$

  = -419.38 kPa

Using Von Mises Stresses theory to calculate the factor of safety:

$$\sigma = \sqrt{\left(\frac{(\sigma_1-\sigma_2)^2+(\sigma_3-\sigma_2)^2+(\sigma_1-\sigma_3)^2}{2}\right)}$$

σ_1 = 730.055 □□□

σ_2 = 0 □□□

σ_3 = −419.38 □□□

Therefore, using the equation we get

□ = 1.007 MPa

Therefore, factor of safety can be calculated using

□ = $\frac{S_y}{\sigma}$

Where:

□□ = 21 □□□ = Yield Strength

- □ = $\frac{21}{1.007} = 20$, This is a very safe design for our project. This also sustains load at higher wind speed.

3.4 Bearing and Bearing Housing

Bearing is used to support and also enable the rotational movement of the shaft while reducing friction and handling stress.

In natural condition due to wind gust, there is vibration occur in turbine or assembly error and for better clearance bearing that is self- aligned is more helpful. So, we choose self-aligned 2 raw ball bearing which has an id of 25mm and od is 47 mm and height is 15 mm.

Fig-7: Deep groove self-aligned ball bearing

- Accommodate static and dynamic misalignment
  The bearings are self-aligning like spherical roller bearings.
- Excellent high-speed performance
  Self-aligning ball bearings generate less friction than any other type of rolling bearing, which enables cooler even at
  At high speeds.
- Minimum maintenance
  Due to low heat generation, the bearing temperature is lower, leading to extended bearing life and maintenance Intervals.
- Low friction
  Very loose conformity between balls and outer ring keeps friction and frictional heat at low levels.
- Excellent light load performance
  Self-aligning ball bearings have low minimum load requirements.
- Low noise
  Self-aligning ball bearings can reduce noise and vibrations levels, for example, in fans.

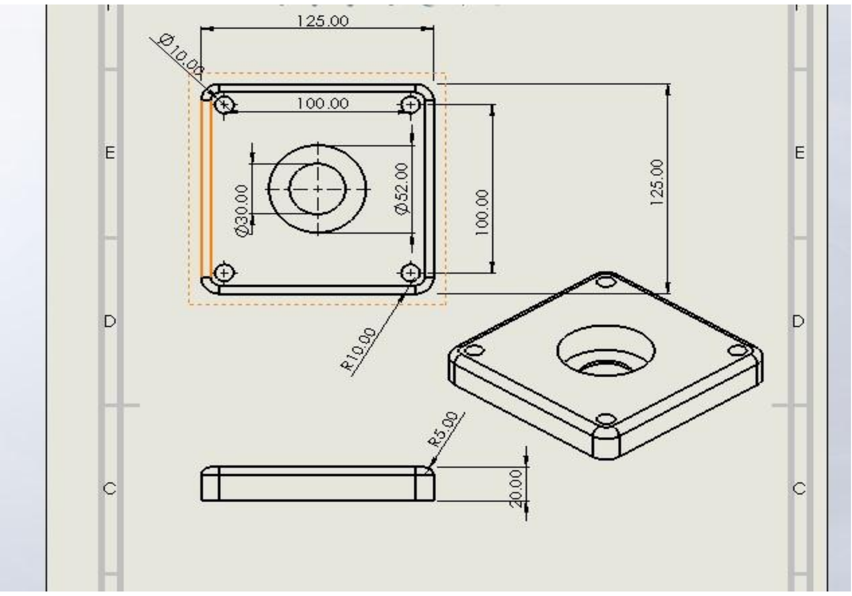


Fig-8: Drafting of bearing housing

3.5 Frame and Blade support

Frame's work in the turbine is to support the turbine. So, weight should not be a big issue for that so for an economic design we can use cheap material like mild steel AISI 1020 which is also used for making street light poles. Also, mild steel can absorb vibration better than the other material. And also, by colouring frame life of the material can be expanded.

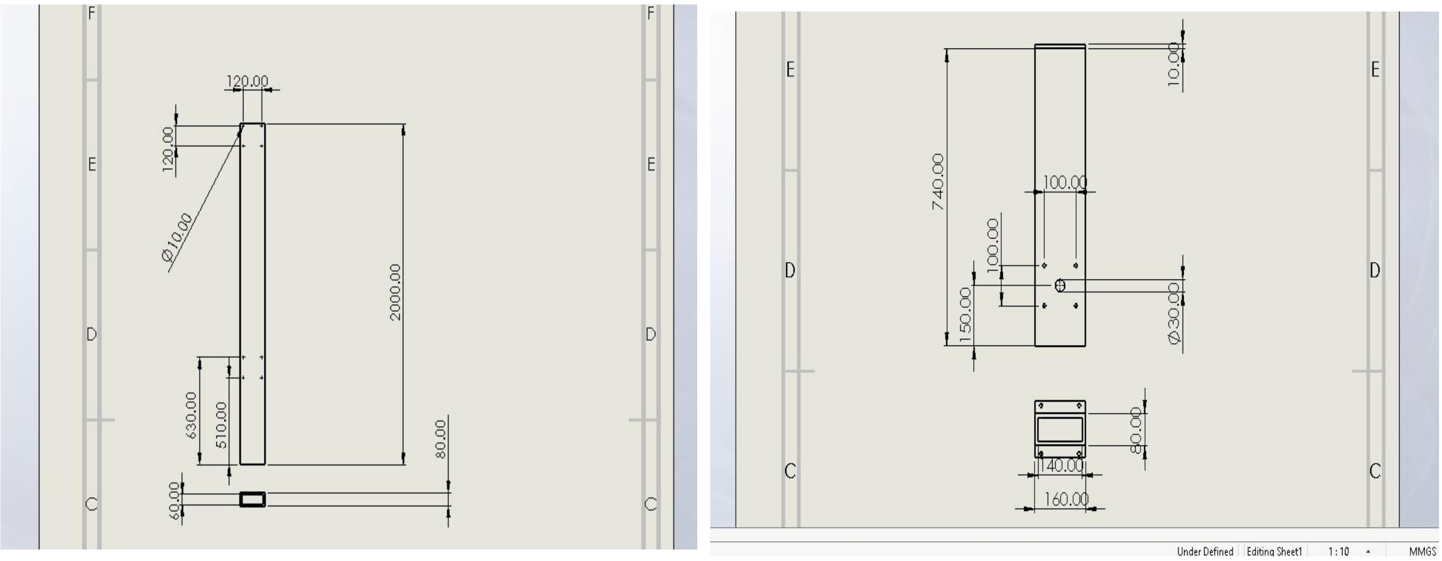


Fig-9: Drafting of the main pole frame

- Blade support is attached with a blade. It also rotates with the turbine body so has to be light-weighted. So aluminium alloy is the best choice of material here. It is also lightweight.
- To reduce weight, we chose this type of design which is given in below figure.
- Design is slim, so it cannot create a resisting force against the wind.

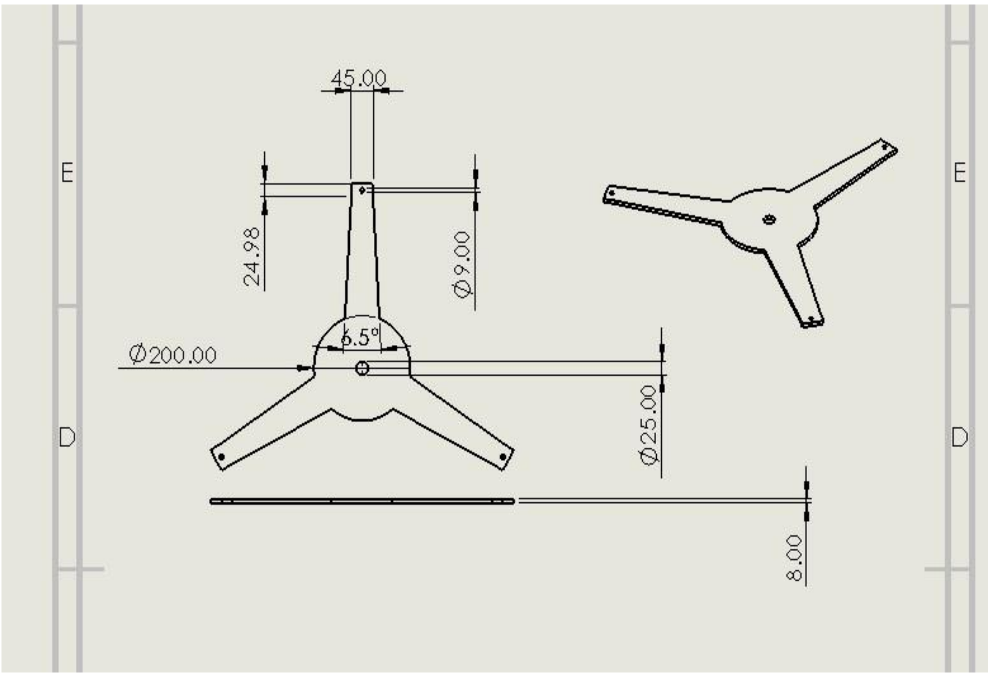
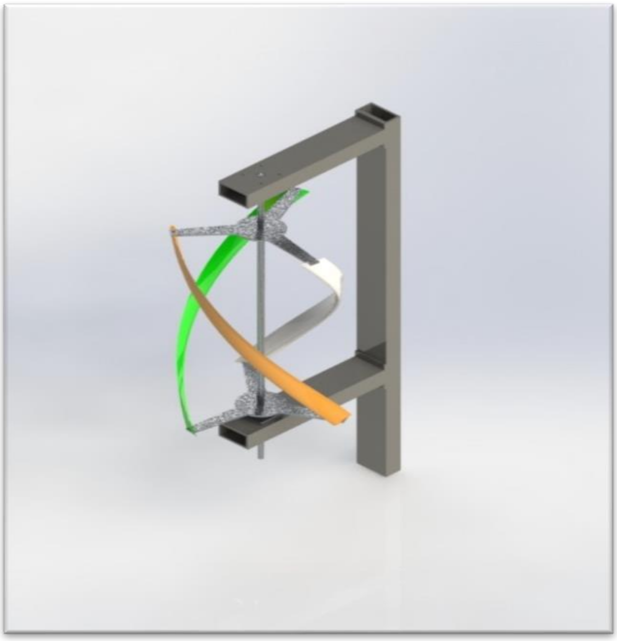


Fig-10: Drafting of the Blade support

3.6 Building Prototype



4. ANALYSIS & TESTING

First, we make the design in Solidworks than we do a CFD study in Solidworks for collecting data that we use in static simulation.

4.1 computational fluid dynamics study

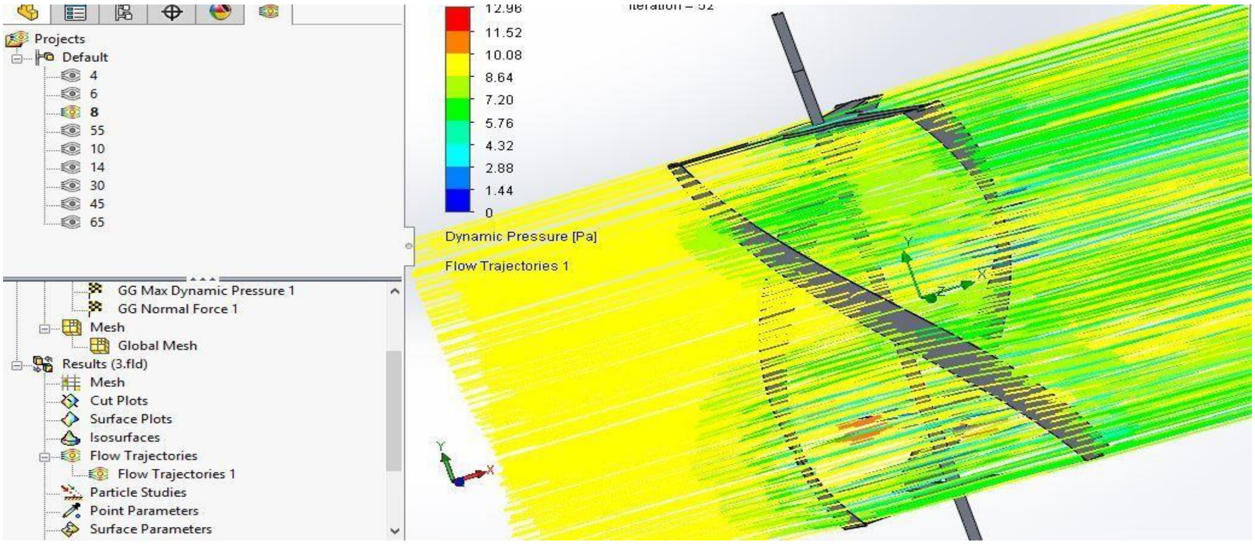


Fig-11: CFD analysis study

We decide the parameter to perform this study like our fluid is air, the wind direction is x-axis direction low of wind is laminar and turbulent. Also, mesh type is 4-point jacobian mesh.

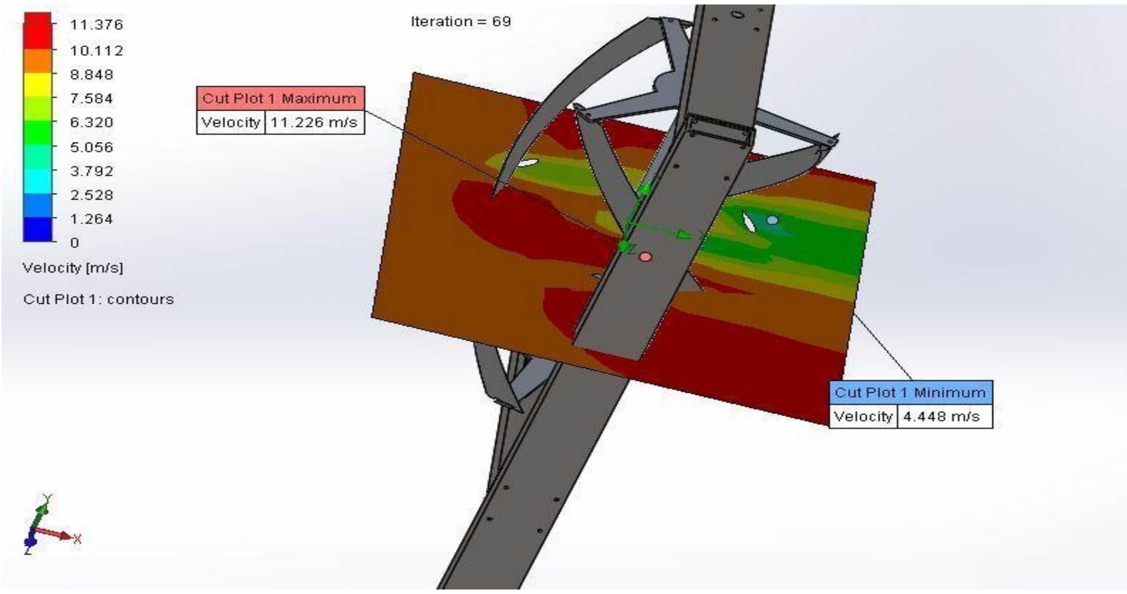


Fig-12: Analysis at wind speed 10m/s

4.2 Static Analysis

Using SolidWorks we were able to predict the static and dynamic behaviour of the turbine by applying flow simulation the static was predicted by applying distributed force on the blades and the shaft as shown in figures below.

Table-3: Static analysis

Total Nodes	**98979**
Total Elements	**55130**
Maximum Aspect Ratio	**28.421**
% of elements with Aspect Ratio < 3	**78**
% of elements with Aspect Ratio > 10	**1.47**
% of distorted elements(Jacobian)	**0**
Time to complete mesh(hh;mm;ss):	**00:00:22**

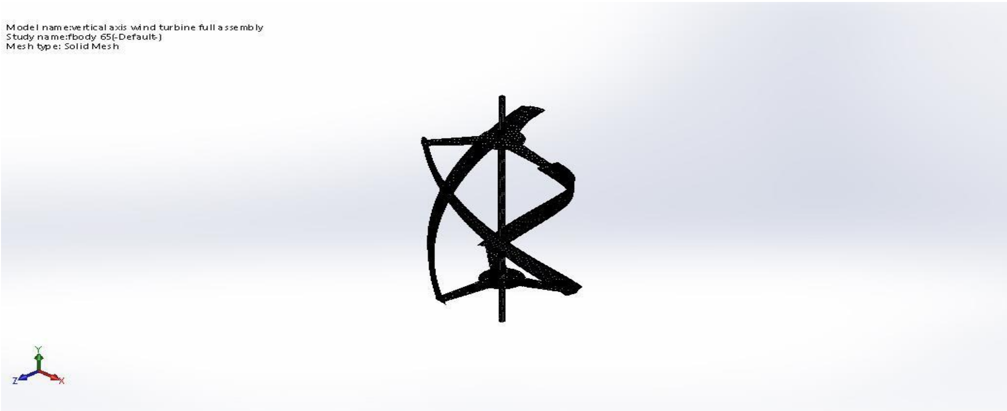


Fig-13: Meshing of body

We implement different wind speed data that we calculated from CFD simulation in the static stimulation and at the wind speed of 65m/s we get the minimum factor of safety for our design that can tolerate the wind load without failure. Which is 3.8

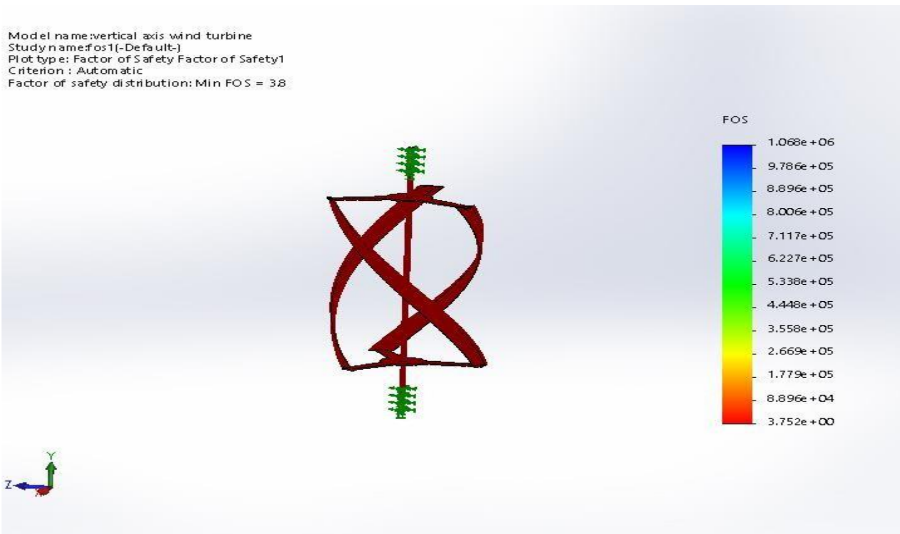


Fig-14: static simulation factor of safety

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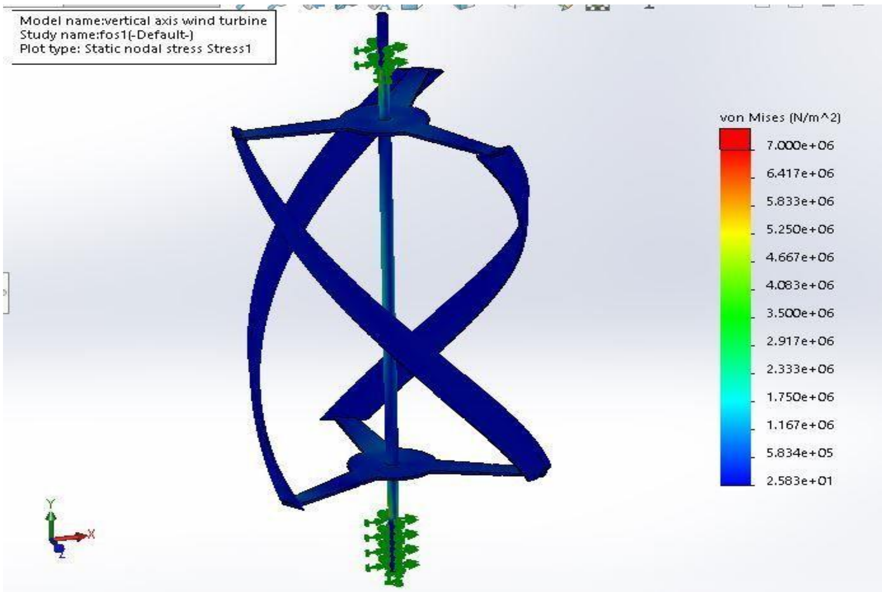


Fig-15: simulation Von-Mises stress static

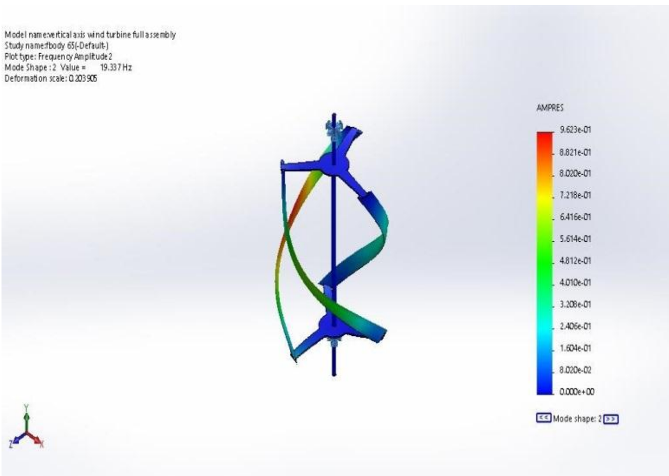
- The turbine is subjected to 65m/s wind speed in the static simulation have Von Mises stress around 1.1 Mpa and have the value of Factor of safety is 3.8

4.3 Dynamic Simulation

The dynamic simulation was obtained via SolidWorks using the flow simulation, as shown in the below table. The frequency 17.186 Hz is faced by the body at the wind speed of 65 m/s.

Table-4: Frequency study

Frequency Number	Rad/sec	Hertz	Seconds
1	107.98	17.186	0.058187
2	121.5	19.337	0.051714
3	121.54	19.344	0.051696



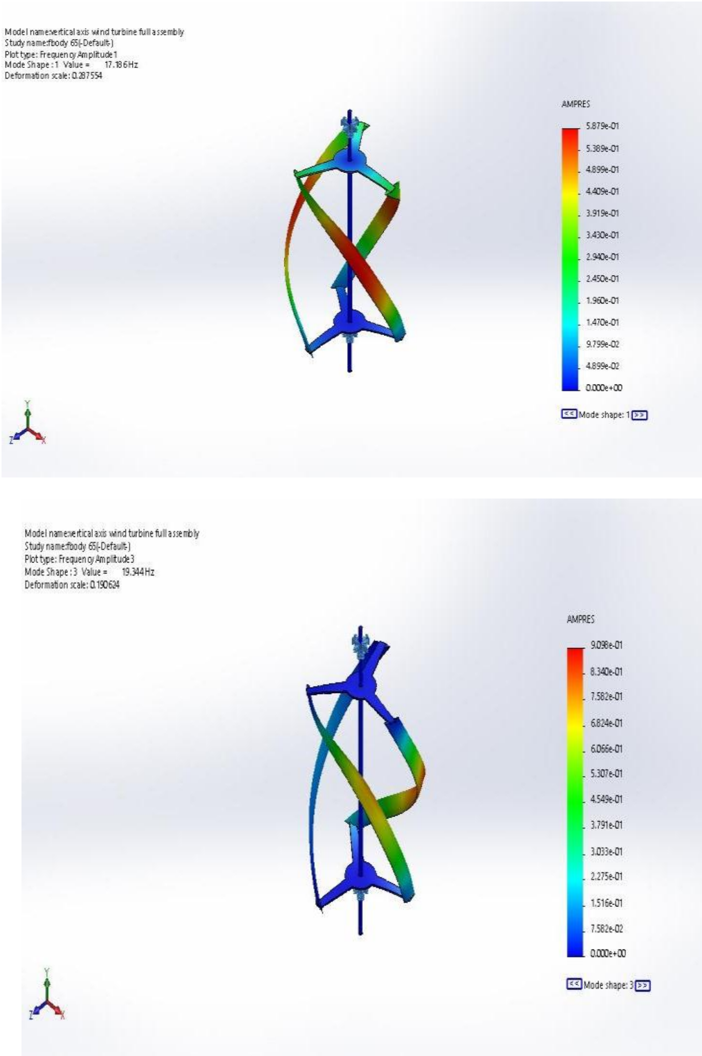


Fig-16: frequency at frequency number 1,2 &3

4.4 Prototype building and testing

For prototype building, converted the Solidwork blade file to .stl and then import in cura3d software. Where all g code for blade generates automatically and also divided into layers. Then we print blades by 3d printing machine. After that, we assemble parts in the college workshop.

We used many machines in the workshop like a grinder, welding machine, drilling machine, and lathe also use the equipment for measuring data and for accuracy of a turbine-like anemometer, spirit level, tachometer, etc. We put the prototype on the SSASIT college's terrace and measure wind data. Also, measure the rpm of the turbine.

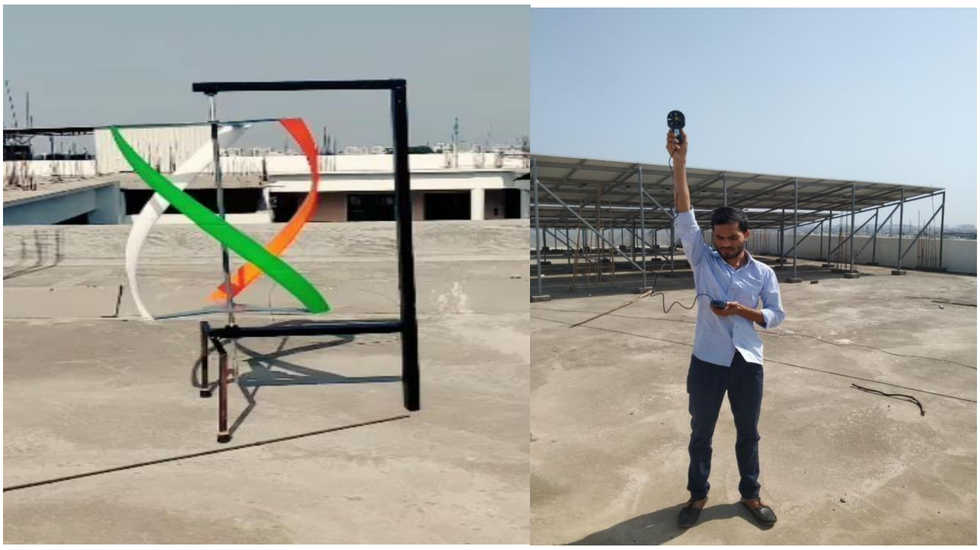


Fig-17: Wind speed data collection

Anemometer is used for calculating the wind speed. By putting a fan at wind facing the direction we can get digital reding with help of the anemometer and Tachometer is used for measuring the rpm of the rotating shaft.

Fig-18: data collection

At last, we calculated Rpm of the turbine at different wind speeds.

Table-5: Model RPM Data

Wind speed (m/s)	Rotation speed(rpm)
3.4	**45.4**
4.1	**54.6**
5	**62.6**
6.3	**71.3**
7.2	**81.3**

8	**85**
8.3	**89.1**
8.5	**95**
9.1	**103**

4.5 Possible Power Output

- $T= 0.5 \times c_p \times \rho \times \left(\frac{A}{w}\right) \times V^3$

Where,
T=torque
c_p= coefficient of performance
ρ = air density
A= area of the turbine
w= rotation in rad/s
V= velocity of the wind

- $c_p = \frac{0.25 \times \rho \times A \times (V+V_1)(V^2-V_1^2)}{0.5 \times \rho \times A \times V^3}$

Where, $V_1 = outlet\ velocity$ from the turbine

- In our prototype, at a wind speed of 8 m/s, we find out that output velocity is 5.46 m/s.
-

$$c_p = \frac{0.25 \times 1.614 \times 0.7 \times (8 + 5.46)(8^2 - 5.46^2)}{0.5 \times 1.164 \times 0.7 \times 8^3}$$

- c_p=0.449 so we take c_p as 0.45
- So the efficiency of this turbine is 45%

- $T= 0.5 \times 0.45 \times 1.164 \times \left(\frac{0.7}{8.901}\right) \times 8^3$
  =10.53 Nm

$$\text{Power} = \frac{2\pi n T}{60} = \frac{2\pi \times 85 \times 10.53}{60} = 93.81 \text{ W}$$

- If we consider or attached with permanent magnet generator which has efficiency around 90% then we get 84.44 W exact power output.

Wind speed (m/s)	Rotation speed(rpm)	Power output(W)
3.4	**45.4**	**7.227**
4.1	**54.6**	**11.332**
5	**62.6**	**20.06**
6.3	**71.3**	**41.229**
7.2	**81.3**	**61.553**
8	**85**	**84.443**

8.3	89.1	94.302
8.5	95	101.376
9.1	103	124.254

Table-6: Power output

5. SUMMARY

- Through numerous testing and careful analysis of the vertical wind turbine, we managed to draw up various conclusions on their effectiveness, and their general importance in the development of clean energy within the affordable price in Gujarat.
- From data we can say that there is power generation happen by turbine if we install the turbine where wind speed is around 8-9 there is continuous 100 W generated by the turbine. Unlike solar energy wind energy can work 24 hours and create **2.4 kWh** of electricity throughout a day.
- One of the important aspects of the vertical turbine is that it does not need to be indicated towards the wind for it to work powerfully. This makes it effective within a territory with shifting wind course which is usually happening in an urban area. Also, it is equipped for working amid insignificant wind speed, which is around 4 m/s that we know by a testing prototype. This is because of its long-curved propellers are intended to be pushed by a little measure of wind force.
- Also from the software analysis, it is concluded that the maximum wind speed can resist by turbine safely is 65 m/s. which is too high wind speed for any urban are. So it is safe for use in this area.
- Further testing has also proven that it does not need to introduce at a higher place. We can put it anywhere where wind speed is around 4 m/s throughout a day. Effectively obvious to natural life, while turning or very still.
- Well by taking a reading from the prototype we can say that it will rotate effectively and if we attach a generator turbine can produce power for daily use.
- When compared to the other turbines, horizontal, we notice that the pros of the vertical outweigh that of the horizontal. By designing in software and manufacturing with the help of a 3D printer a hollow, lightweight, exact shape and size blade can be manufactured.

Application and future scope

1. This design turbine is not consuming too much space so it can use at many places for producing power like at rooftop, on street poles, etc.
2. Because of low vibration and noise structure it can use at the home roof, at the educational building, public space, government building, etc.
3. We can install on the divider of the highway so due to moving vehicle wind speed turbines can generate electricity that uses for street light and other applications.
4. If we are using high-grade carbon fiber material we can install at the high chimney, on a boat or at a border of a country where electricity is not available.
5. These days the electricity rate is increasing. So we have to create electricity from renewable energy sources like wind. Where there is no electricity the area which is far away at that place this can be a solution for power generation like in the jungle, or in the middle of a dessert, at the border of any country, on an island, etc.
6. This is a new field to work so there are many ways that we can improve turbine efficiency. For more electricity generation we can mount solar panels on the roof of the turbine that gives us more benefits for power generation.
7. By applying gear-box the speed ration can be increased and more power can be generated.

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