Vertical Axis Wind Turbine for Building Application

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Abstract - *Wind is non-conventional form of energy. we can generate electricity with the help of affluence wind energy. aim of this project is you also take maximum advantage of wind energy in effective manner to get the maximum electricity output. Therefore, we design vertical Axis wind turbine (VAWT) and select terrace of G+4 commercial building so we can take advantage of maximum wind speed.*

VAWT cheaper than the horizontal axis wind turbine although VAWT are more suited for urban area because they produce less vibration leads to less noise population and le structural damage.

In this project we created small model for testing purpose. This work also aims to maximum output with minimum cost. So, we can establish this type of VAWT on terrace of building.

Key words: Darrieus Turbine, Gorlov Turbine, Vertical Axis Wind Turbine

1. INTRODUCTION

Wind is caused by difference in atmospheric pressure. When a difference in atmospheric pressure exists, air moves from the higher pressure to the lower pressure, resulting in winds of various speeds. Other factors which affect the wind are heating of earth's surface, irregularities of earth's surface and rotation of earth about its own axis. Energy produced by this blowing wind is called wind energy.

Electricity is most important thing in our day to day life. Morden means of transportation and communication have been revolutionized by electricity. So, production of electricity is one of the main aims of Country. Electricity is most often generated by electromechanical generators which are operated by fuels like diesel, coals, etc which also creates pollution and global warming. Therefore, power generation with the help of non-conventional resources such as solar and wind is increasing day by day and this type of generation is very clean and safe.

There are basically two types of wind turbine:

1.Horizontal Axis wind turbine
2.Vertical Axis wind turbine

HAWT requires yaw mechanism where VAWT can produce power independent of wind direction. Another advantage of VAWT is, it requires less money for production compared to HAWT and it is also affordable in maintenance cost compared to HAWT.

A VAWT is a type of wind turbine where main rotor is set perpendicular to wind streamlines and vertical to the ground. Other components are connected with top or base or may be top and base of turbine.

VAWT are further classified in:

1. Savonious VAWT
2. Darrieus VAWT
3. Giro Mill

Aim of the project is to utilise maximum amount of wind energy and hence we selected as of G+3 storey building.

2. PROPOSED MODEL

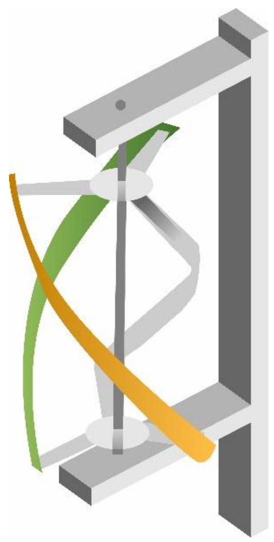

Fig 1 - Proposed Model of VAWT

3. MATERIAL USED

Material for blades, shaft, bearing, frame, blade support are listed below.

Table 1 - Material Used

Sr. No.	Component	Material	Cost
1	Blades	Polylactic Acid Plus (PLA+)	Low
2	Shaft	Aluminium	Low
3	Bearing	Chrome Steel	Moderate

4	Frame	Mild Steel	Low
5	Blade support	Aluminium	Low

4. DESIGN OF COMPONENTS

This work requires lots of parameter to be taken into account, like the speed of the wind impacting on the blades when turbine get start rotating. Turbine required an open area preferably high mounting area available on rooftop. For the support, body design is done in that way so it can absorb maximum vibration which produced by turbine.

4.1 Blade Design

$$\sigma = \frac{B * C}{\pi * D}$$

σ: Solidity
B: Number of Blades
C: Chord Length
D: Diameter of turbine

Rearranging the equation:

$$C = \frac{\sigma * \pi * D}{B}$$

$$C = \frac{0.15*3.14*0.7}{3} = 110\text{mm}$$

So, we decide chord length as 110mm as our diameter of blade is700mm and also height of blade is 1000mm.

4.2 Shaft Design

Shaft is subjected to two forces and a torque, the torque resulting from the rotation of blades due to wind orthogonal to shaft.

The stresses on the shaft are : $\sigma_x = \frac{P_w}{A}$
Where:

P_w= Wind load on the blade
A= Cross section area of the shaft $A = \frac{\pi D^2}{4}$
D= Diameter of Shaft= 0.025m
$A = \frac{\pi*0.25}{4}$ = 0.0005m3

Therefore,

$$\sigma_x = \frac{6.86}{0.0005} = 13.72 \text{ KN}$$

And

$$\sigma_y = \frac{w}{A}$$

Where:

W= Wind load on the blade
A= Cross section area of the shaft

$$\sigma_y = \frac{104.48}{0.0005} \leq 296.96 \text{ K*Pa}$$

Torsion of shaft can be calculated by:

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

We use Mises Stresses theory to calculate factor of safety = 20.

4.3 Bearing Design

Bearing is used to support shaft and also used to allow rotational moment of shaft. While reducing friction and handling stress.

Due to wind gust there is vibration occur in turbine or assembly error and for better clearance bearing that is self-aligned is more powerful. So, we choose self-aligned 2 raw ball bearing.

Advantages:

- Excellent high-speed performance
- Minimum Maintenance
- Low friction
- Low noise
- Excellent light load performance

Fig 2 - Ball Bearing

4.4 Frame Design

Main role of frame in turbine is to support the turbine. We want to make economical model so we used material like mild steel. Which is also used for making street light poles. This material can also absorb vibration better than other material. We coloured so duration of material is increase.

4.5 Blade support Design

Blade support is to connect blade and shaft rod and also eat rotating with shaft due to wind impact on blade. Here also lightweight aluminium alloy material used to make blade support also it protect by erosion effect against weather condition.

Fig 3 - Blade Support

5. VARIOUS OPERATION INVOLVED IN FABRICATION PROCESS

Following fabrication process are involved:

1. Shaping process
2. Machine process
3. Cutting
4. Welding
5. Surface finishing

6. POWER CALCULATION

For calculation of air density, we use following equation:

$$\rho = \frac{P}{Rt}$$

Where,

P= 101325 pa
R= Gas constant 287.05J/Kg K
t= 30+273=303 K

$\rho = \frac{101325}{287.05*303}$ = 1.164 kg/m3

So, we get air density= 1.164 kg/m3

The turbine is going to fit in small space area so size should be optimal therefore we choose dimension of turbine within 1 meter. We put constrain that factor of safety is greater than 1 and stress would be minimized.

Turbine radius r= 0.7/2= 0.35 m
Let wind speed from average result data, V= 7 m/s

λ_{avg}=$\frac{2.5+5}{2}$= 2.25

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

Thus

$$T = \frac{0.5 * c_p * \rho * A * v^3}{\omega}$$

Where,

A= 1*d= 1*0.7= 0.7m2

By putting this value, Torque T= 1.707 Nm

Pflow = 0.5* ρ*A*V3
= 0.5*1.164*0.7*73
= 139.73 W

Pturbine = Pflow*Cp
= 139.73*0.55
= 76.85 W

7. TESTING AND RESULT

Table 2 – Testing

Sr. no	Wind Speed (m/s)	Wind Speed (km/hr)	Power Generation (W)
1	4	14.4	24.3
2	6	21.6	46.39
3	7	25.2	75.89
4	8	28.8	114.72
5	10	36	224.96
6	12	43.2	385.7
7	14	50.4	613.57
8	16	57.6	918.32

8. CONCLUSION

Through numerous testing and careful analysis of the vertical ais 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 Gujrat.

Also, from the software analysis it is conclude that the maximum wind speed can resist by turbine safely is 63 m/s. Which is too high for any urban area. From the analysis of prototype, we can say that it will rotate effectively and it can produce power for daily use.

9. FUTURE SCOPE

- This designed turbine does not require more space.
- Because of low vibration structural damage is minimum So, we can place this turbine in ant governmental or residential or commercial building.
- If we are using high grade carbon fibre material we can install at high chimney, on a boat or at a border of country where electricity is not available.
- This is new field to work so there are many ways that we can improve turbine efficiency.
- By applying gear-box the speed rotation can be increased and more power can be generated.
- By setting different angles at different speed of the turbine can also be done as a future work or scope.

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