Design of Vertical Axis Wind Turbines for Electricity Generation

Hemant Gajanan Teli[1] Yogesh Ramchandra Kokare[2] Prof. M. T. Sawant[3]
[1,2]Student [3]Professor
[1,2,3]Department of Mechanical Engineering
[1,2,3]SSPM'S College of Engineering, Kankavli, India

Abstract— One of the best sources of energy that can apply the concept of sustainability is renewable energy such as sun, wind, and rivers. The positive point of wind energy is that it is useful all the 24 hours all the year. This paper discuss the designing and manufacturing a wind turbine that can convert wind by using Vertical Axis Wind Turbines (VAWT) to a useful energy. Here we will discuss how the electricity will be collected from highway by using Vertical Axis Wind Turbine. (VAWT). By this method the overall cost per unit of energy produces is less than the cost of new coal, natural gas and its installation. So the implementation can be made easier than any other methods. The dynamo is connected to the either upper part or lower part of the wind turbine which works on Fleming's left hand rule of Electromagnetic induction.

Key words: VAWT, HAWT, CAD Design

I. Introduction

Wind energy is the fastest growing source of clean energy worldwide. Asia accounted for 35% of the global installed wind power capacity at the end of 2011. Total installed capacity in the United States was 47 GW (20% of the global total), in Germany it was 29 GW (12%), in Spain it was 22 GW (9%) and in India it was 16 GW (7%)[1]. So the employment of wind energy is expected to increase dramatically over the next few years according to data from the Global Wind Energy Council.

There is a near constant source of wind power on the highways due to rapidly moving vehicles. This concept is green source of energy and has no effect on the life of earth. These wind energy turbines are small and can produce up to 300 watts for each turbine. This involves mounting of vertical axis wind turbines on the divider of the roads that would be driven by the moving air generated by the passing traffic. Average vehicle speeds on the valley highways are approximately 70 mph. This power production estimate will increase exponentially with an increase in wind turbulence speed[1].

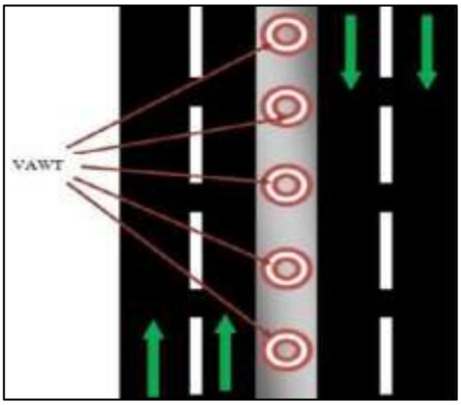

Fig. 1: Turbine on Highway Divider[1]
[Shweta Singh et.al 2010]

In addition to that, energy generation from fossil fuel may cause so many environmental problems. Renewable energy sources play a major role in these type of situation. Renewable energy is the energy that extracts from renewable sources such as Winds, Sunlight, Rain,Tides,Waves, Geothermal heat etc.

II. Literature review

E.A.D. Kumara, N.K. Hettiarachchi, explained the behaviour of the Vertical Axis Wind Turbine (VAWT), present technological state, new finding through modelling work and future direction of VAWTs were reviewed. They studied the behaviour of the Vertical Axis Wind Turbine, present technological state, new finding through modelling work and future direction of VAWTs.

Shweta Singh, Sarita Singh and Priyank Srivastava discussed about harnessing electrical energy from the highway vehicles. This would involve mounting vertical axis wind turbines at the centre of the roads that would be driven by the moving air generated by the passing traffic.

In the project report of "Vertical Axis Wind Turbine dynamics and Noise" of Erik Mollerstorm has two main topics both regarding VAWTs: eigenfrequency of the tower and the noise generated from the turbine. The eigenfrequency of a semi-guy-wired tower is studied and an analytical expression describing this is produced and verified by experiments and simulations. The eigenfrequency of the wire itself and how it is affected by wind load are also studied.

Mubarak Jazzaa N Alharbi explained the design of aeroleaf wind turbine. The project is about designing and manufacturing of an Aero leaf Wind Turbine that can convert wind by using Vertical Axis Wind Turbines (VAWT) to a useful energy.

In the project report of Danish Energy Authority, studied the total noise emission increase with increase in the nominal power of the turbine. Calculation scenarios at adjacent residencies to wind turbine with determination of low frequency noise levels indoor have been carried out.

III. Problem definition

In this concept the output of the VAWT is used only for street light and in this no one can mention about streamline flow i.e. the shapes of turbine blades makes big difference in output of the turbine.

Our main aim is produce maximum electricity and store it for our future generation because in future the more possibilities to shortage of fuel will taking place, and for handle and recover this situation we proposed our own design and analysis, that is more efficients. The big problem in now a days is fuel, day by day amount fuel decreases rapidly and this problem will face our future generation and we want to minimize this problem from this concepts

IV. BASIC PRINCIPLE OF VERTICAL AXIS WIND TURBINE

There are two types of turbines: Vertical Axis Wind Turbine (VAWT) and Horizontal axis wind turbine (HAWT). Normally, Horizontal axis wind turbine (HAWT) gives high power output than Vertical axis wind turbine (VAWT). But, HAWT needs high speed of air velocities (around Rating speeds) to give its maximum performances. And also, moving wind turbine blade experiences the wind relatively. There are two main types of VAWTs called the drag driven VAWT (Savonius type) and the lift driven VAWT (Darrieus type). The Savonius type functions similar to a water wheel that uses drag forces. On the other hand, the Darrieus type has blades similar to the HAWTs[2].

VAWTs offer a number of advantages over traditional horizontal-axis wind turbines (HAWTs). They can be packed closer together in wind farms, allowing more in a given space. They are quiet, Omni-directional, and they produce lower forces on the support structure.

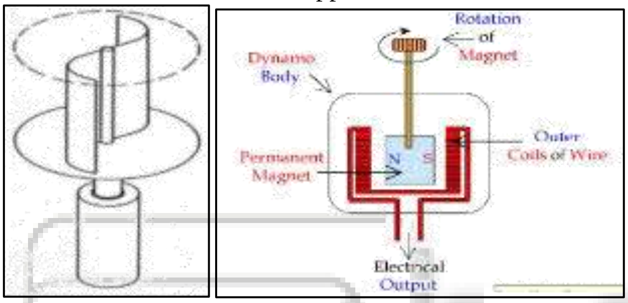

Fig. 2: Savonius type Vertical-Axis Wind Turbine[2]
[E.A.D. Kumara, et.al 2017]

They do not require as much wind to generate power, thus allowing them to be closer to the ground where wind speed is lower. By being closer to the ground they are easily maintained and can be installed on chimneys and similar tall structures.

V. CONSTRUCTION

Wind turbine blades have on aero foil type cross section and a variable pitch. The ideal wind generator has an infinite number of infinitely thin blades. In the real world, more blades give more torque, but slower speed, and most alternators need fairly good speed to cut in. 2 bladed designs are very fast (and therefore perform very well) and easy to build. The ideal tip speed ratio depends on rotor diameter, blade width, blade pitch, RPM needed by the alternator, and wind speed.

For the shaft of the turbine, use of steel over a lighter metal such as cast iron was based on the availability of materials. The top and bottom ends are fixed to give strength to the hollow shaft. A solid rotating shaft is assumed to be made of mild steel. [1]

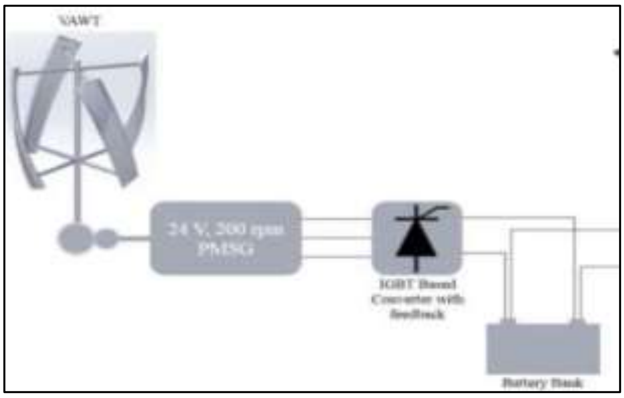

Fig. 3: Schematic Diagram[1]
[Shweta Singh et.al 2010]

A dynamo is used for generation of electricity. A charge controller is needed to control the overcharging of the battery. We can store energy in battery without reverse flow and current.

VI. WORKING

The original version of Darrieus designs was symmetrical and had zero rigging angles. This arrangement is equally effective regardless of the direction in which the wind is blowing. Darrieus type needs an electric support to start, and its removal rate around 4-5 m /s, while the Savonius type starts at 1 m/s or lower. By solving the staring problem of the Darrieus type turbine, the hybrid system has been introduced. That system combines the Savonius type which staring at low speeds. Darrieus type takes high power coefficient (Cp) than the Savonius type at high-speed winds.[2]

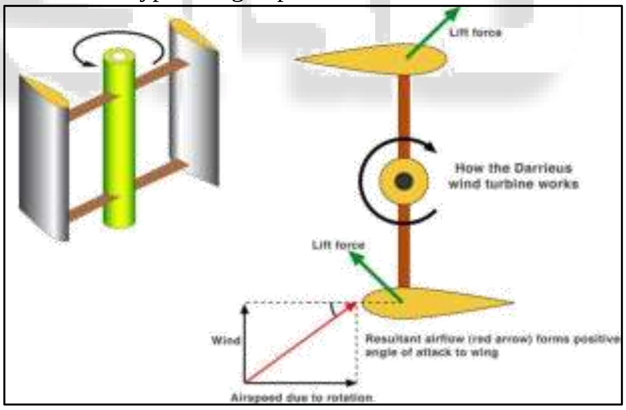

Fig. 4: Darrieus Wind Turbine Operating Principle,[2]
[E.A.D. Kumara et.al 2017]

VII. PROPOSED DESIGN & ANALYSIS

A. Calculation

1) Power Calculations

The wind turbine works on the principle of converting kinetic energy of the wind to mechanical energy. The kinetic energy of any particle is given by,

$$K.E=\frac{1}{2}mv2 \quad (1)$$

Where,
K.E = kinetic energy
m = mass
v = velocity,

M is equal to its Volume multiplied by its density _ of air

M = _AV (2)

Substituting eq. (2) in eq. (1)

We get,

K E = ½_AV.V2

K E = ½_AV3watts.

Where,

A= swept area of turbine.

_= density of air (1.225 kg/m3)

V=wind velocity.

For 40 Watt power, calculate design parameters of turbine, P=40 watts.

Considering turbine efficiency as 35% and generator efficiency 90%,

P = 40/ (0.35*0.90)

P= 126.98 watts.

= ½_AV3

For wind velocity 6.67 m/s (18mph)

Density of air (1.225 kg/m3)

126.98 = ½*1.125*A*(6.67)3

A= 0.76 Sq.m

A = D*H (Sq.m)

D= diameter of the blade

Taking diameter as 1 meter, height of turbine can be calculated as,

H=A/D =0.76/1

H =0.76m.

Diameter and height of wind turbine are 1m and 0.76m respectively.

2) Design of Turbine Blades

Wing width= diameter*0.14

= 1*0.14

= 0.140m = 140 mm

Wing chord = circumference*.09

= pie*1*.09

= 0.282m = 282mm

3) Torque on Turbine

As we know that, power=2*pie*N*T/60

Power=126.98watt

And,

V=2*pie*N

Consider minimum average speed of vehicle on highway=30kmph i.e. V=500m/s

Now,

500=2*pie*N

N=80rpm

And also,

40=2*pie*80*T/60

T=0.0795N-m

B. *CAD Design*

1) Blades

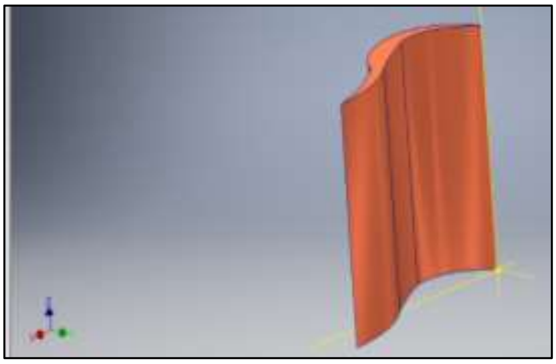

Fig. 5: Blades

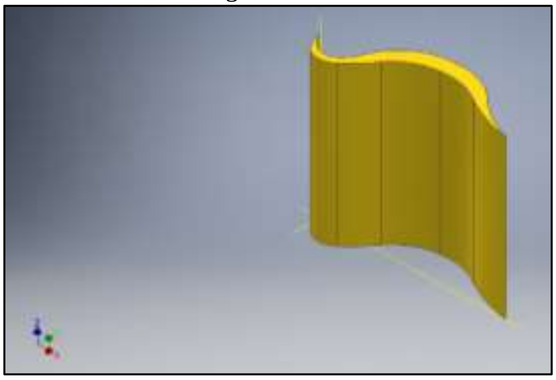

Fig. 6: Blades

2) Assembly

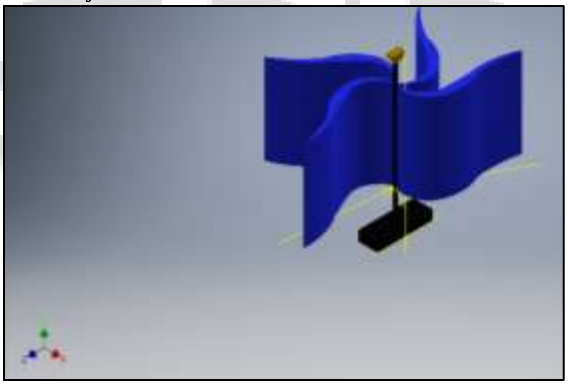

Fig. 7: Assembly

C. *Analysis*

1) Stress Analysis

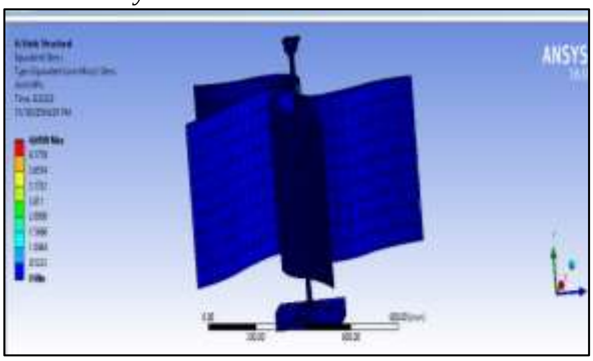

Fig. 8: Stress Analysis

Here maximum stress is less than the yield stress of material hence design is safe and will get maximum efficiency.

2) Deformation

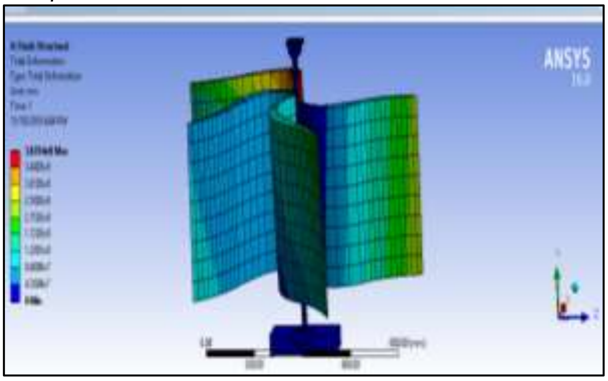

Fig. 9: Deformation

3) Conclusion from Analysis

First thing is our blade section is like aerodynamic in shape and If you use any shapes instead of aerodynamic or any gradually decreasing area shapes for blades then you will not get the maximum efficiency because shape will change, more torque will applied on blade and blades are rotate in very low speed that is effects on output of turbine i.e. less electricity will be generated.

VIII. ADVANTAGES

1) They are less affected by turbulent air than standard horizontal-axis wind turbines. [1]
2) Have lower installation costs for the same height as horizontal-axis wind turbines. [1]
3) They require lower wind speeds to generate the electricity, which increases their capacity to serve areas with lower than average wind speeds. [1]
4) They rotate at one-third to one quarter the speed of horizontal-axis turbines, reducing noise and vibration levels, but at the expense of lower efficiency. [1]

IX. FUTURE SCOPE

In future there is huge possibilities to invent vehicles runs on electricity because of rapidly decreasing the storage of fuel, and our main aim from this concept is to make electric power station at particular distance from this people use this in emergency to charge their vehicles and get startup to reach their destiny.

The efficiency can be increased by precise fabrication of prototype and also by designing the blades of the turbine more aerodynamically and use simulation software like CFD. The development of effective alternators and dynamos can be used to harness wind energy from relatively small winds. The use of materials like Acrylic Plastic Sheets can be used to develop low cost VWAT.

X. CONCLUSION

Our work and the results obtained so far are very encouraging and reinforce the conviction that vertical axis wind energy conversion systems are practical and potentially very contributively to the production of clean renewable electricity from the wind even under less than ideal siting conditions this project will be helpful in rural areas where the electricity supply is scarce. Also in most cities, bridges are a faster route for everyday commute and in need of constant lighting makes This an efficient way to produce energy

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