International Journal of Technical Research and Applications e-ISSN: 2320-8163,
www.ijtra.com Volume 10, Issue 5 (SEPTEMBER-OCTOBER 2022), PP. 13-18

DESIGN AND FABRICATION OF VERTICAL AXIS WIND TURBINE

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***Abstract*— Kenya faces problems in increasing the share of wind energy in the state's electricity mix. It is difficult to add more Horizontal Axis Wind Turbines (HAWTs) to wind farms because of the negative impacts they create for each other when placed too close together. It is also increasingly expensive to permit, buy land, build roads and provide transmission lines for new wind farms. Further, large HAWTs pose threats to migratory and native bird populations, resulting in additional costs and difficulties in obtaining permits and developing environmental impact mitigation plans.**

The use of Vertical Axis Wind Turbines (VAWTs) as a solution to these problems has not yet been investigated, due to lack utility scale VAWTS and data on their impacts to neighboring HAWTs and wildlife. Before wind farm owners will allow the large-scale deployment of VAWTs near HAWTs, field research must demonstrate that wakes produced by VAWTs have neutral or positive effects on the energy production and maintenance of nearby HAWTs. Before permits can be obtained for installation of VAWTs in most Kenya wind farms, research must demonstrate that the turbines do not negatively impact bird populations.

The technical and economic feasibility of Vertical Axis Wind Turbines [VAWTs] has also been largly unexplored to dae, but the inhere nt advantages of VAWT suggests a transformational opportunity to allow access to vast wind resource sites such as off the Eastcoast of Kenya and north part of Kenya.

***Index Terms*— Design a Vertical axis Wind Turbine, Check efficiency of the VAWT, HAWTs.**

I. INTRODUCTION

This project is about designing and manufacturing of a Wind Turbine that can convert wind by using Vertical Axis Wind Turbines (VAWT) to a useful energy. The current power demand in Kenya is very high compared to power consumption average. This high demanding should take the focus of attention in thinking in different sources of energy.

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 unlike solar energy that only used with sunlight, wind turbine can be useful all the 24 hours all the year.

Another concept of sustainability is the way that we should use in utilizing this renewable energy efficiently, and environmentally friendly. This in turn will eliminate the environment hazard and improve Kenya's health and life style.

Streets, public parks, schools and public facilities are consider as main power consumers, these consumers should be vulnerable to wind from time to time. The idea of this project is to convertthis wind by using Vertical Axis Wind Turbines (VAWT) to a useful energy by using it as a power source that can serve these consumers.

PROJECT OBJECTIVES

Main objective

The main objective of the project is to design and fabricate a small scale vertical axis wind turbine.

Specific objectives

- To collect wind data around Moi University and analyze it.
- To survey and identify the best location for its installation.
- To identify best materials for use in fabrication.
- To recommend if its use is efficient

II. LITERATURE REVIEW

Energy is the main economy base of any country. Sources of energy are not easy to have. Having multiple sources of energy is extremely important to secure the basic living requirement of any country. Utilizing the nature could help in converting some of the natural phenomena such as sun, wind, sea and oil into useful energy. This kind of energy called renewable energy. Science Daily Research Newspaper has defined renewable energy as a form of energy resource that is replaced rapidly by a natural process such as power generated from the sun or from the wind.

Recently, the increasing demand of renewable energy is very well noticed. According to a report by the International Energy Agency, the increase of amount of electricity produced from renewable sources increased from just over 13% in 2012 to 22% the following year.

They also predict that that figure should hit 26% by 2020.

The traditional power plants in Kenya are mainly working on the fuel either gas or oil which are not environmental friendly.

EcoSpark environmental charity has considered oil power plants as one of the most contributors of environment pollution. EcoSpark environmental charity has listed the below most significant environmental impacts:

Oil causes air pollution and greenhouse gas emissions. Oil uses large amounts of water, and creates water pollution and thermal discharge. Oil creates hazardous sludge and solid waste. Extracting and refining oil is environmentally destructive. Transporting oil is risky and can harm the environment. Oil is a non-renewable electricity source.

Such of the above environment affects lead us to think seriously about the renewable energy sources, which will eliminate the environment hazard and improve health and life style.

Wind energy is one of the most important energy sources. The concept of wind energy is transforming the wind's kinetic energy into mechanical energy. This energy drive blades that turn generators that produce electricity. Our project is fitting with wind energy source. The idea of this project is to convert the wind by using Vertical Axis Wind Turbines (VAWT) into power.

They are two types of wind turbines,

Horizontal Axis Wind Turbines (HAWT) as shown infigure 2.1 that is more commonly used across the world and they are used as a power plants. These kind of turbines are the most efficient of wind turbine.

However, the blade span of horizontal wind turbines is larger than vertical axis machines which limits placement confined spaces. Some people also find the large blade area of horizontal axis machines objectionable.

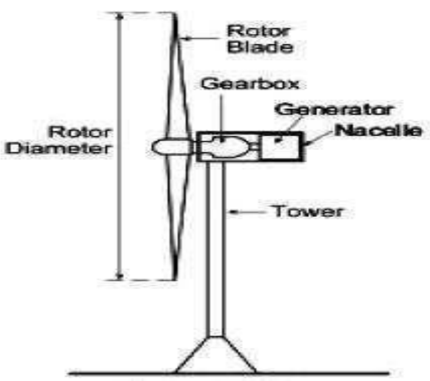


Figure 2.1: Horizontal Axis Wind Turbine

The other type of wind turbine is the Vertical Axis Wind Turbines (VAWT) as shown in figure 2.2.

VAWT is the most popular of the turbines that people are using to make their home a source of renewable energy.

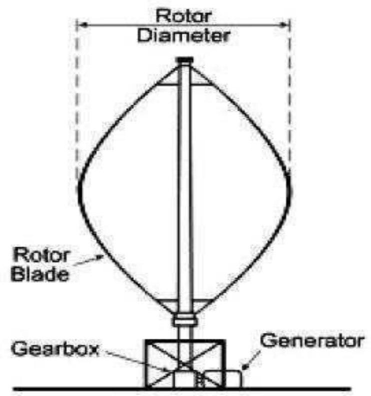


Figure 2.2: Vertical Axis Wind Turbine

VAWT is not as commonly used as the Horizontal Axis Wind Turbine. The reason behind that is that VAWT is less efficient than HAWT when considered as a power plant generator. However, for the small scales like homes, parks, or offices VAWT is more efficient.

Vertical axis turbines are powered by wind coming from all 360 degrees, and even some turbines are powered when the wind blows from top to bottom. Because of this versatility, vertical axis wind turbines are thought to be ideal for installations where wind conditions are not consistent, or due to public ordinances the turbine cannot be placed high enough to benefit from steady wind. Figure 3 shows the configuration of HAWT vs VAWT.

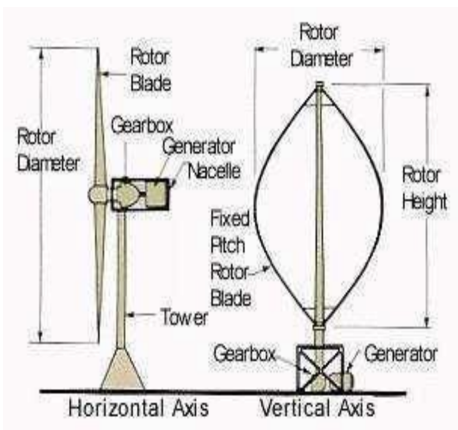


Figure 2.3: Comparison of HAWT and VAWT

WIND ENERGY

Wind is generated from solar energy unevenly heating the earth. This uneven heating creates pressure changes in the atmosphere, generating wind. This wind can then be harnessed by a windturbine. As the wind pushes the blades of a turbine, a generator attached to the axis of the shaft and when spun creates electricity that can be sent to the grid and used in households for electricity. (windies.gov, 2012)

Wind turbines are a clean way to generate power, yet there are many significant problems with them as well. One problem is that they are extremely expensive to design and install, and in order to generate enough energy for communities and cities require space for wind farms. Another issue is that they have to be created in locations where there is enough wind energy to generate enough electricity to justify the cost of the machine.

III. METHODOLOGY

Prior any appropriate solution can be developed, a thorough investigation has to be conducted in order to find out what solutions have already been proposed (information gathering). Once these solutions have been analyzed and the team has an understanding of why the respective solutions are not currently being implemented, a solution generation phase is taking place. Here various solutions are presented and evaluated against criteria and constraints (concept generation). Solution concepts are then modeling The results of the models are then analyzed and the model, as well as solution parameters, may be tweaked (model analysis and refinement).

Once the team has satisfactorily modeled all solution concepts of interest, the concept that performs best analytically, in addition to meeting all criteria and constraints, is selected (concept selection). The analytical model may then be verified experimentally, using a smallscale modeling scheme or through a full scale experimental model.

We designed two models as shown

Fig 3.1: Model (a)

Figure 3.2: Model (b)

Through SOLID WORKS software, model (b) was much efficient. Therefore we concluded to fabricate model (b).

MAJOR COMPONENTS OF VAWT

1. Turbine blade
2. Shaft
3. Alternator
4. Hub
5. Spokes

FINAL APPEARANCE OF OUR FABRICATED VAWT

Figure 3.3: final part

IV. RESULTS

Wind turbines work by converting the kinetic energy in the wind first into rotational kinetic energy in the turbine and then electrical energy that can be supplied, via the national grid. The energy available for conversion mainly depends on the wind speed Swept area of the turbine.

Air density

A German physicist Albert Betz concluded in 1919 that no wind turbine can convert more than 16/27(59.3%) of the kinetic energy of the wind into mechanical energy turning a rotor. To this day, this is known as the **Betz Limit or Betz' Law.** The theoretical maximum power efficiency of any design of wind turbine is 0.59 (i.e. no more than 59% of the energy carried by the wind can be extracted by a wind turbine). This is called the "power coefficient" and is defined as:

Also, wind turbines cannot operate at this maximum limit. The Cp value is unique to each turbine type and is a function of wind speed that the turbine is operating in. Once we incorporate various engineering requirements of a wind turbine - strength and durability in particular - the real world limit is well below the Betz Limit with values of 0.35-0.45 common even in the best designed wind turbines. By the time we take into account the other factors in a complete wind turbine system - e.g. the gearbox, bearings, generator and so on - only 10-30% of the power of the wind is ever actually converted into usable electricity. Hence, the power coefficient needs to be factored in equation (4) and the extractable power from the wind is given by:

ACTUAL/ OBSERVED VALUES

Using our Arduino infrared sensor, we were able to measure the revolutions per minute on wind turbine. Using a tachometer, we were able to measure the revolutions produced by alternator per second. For battery charging to occur, the alternator's voltage must exceed the battery's voltage.

Alternator may not generate sufficient charging voltage until alternator speed is greater than about 2000 RPM. Typically, alternators have their full output rated at 6000 RPM but can continue to spin up to 12,000 RPM or more without any additional increase in output. The speed of an alternator is different for different type of car. The speed of an alternator depends on the speed of the engine. For a racing car, the ratio speed between engine and alternator is usually 1:1. For a drag car, the ratio is usually 1:2. And for street use, the ratio is usually 1:3.

When voltage causes current to flow, energy is converted. This is described as power.

The unit of power is the watt. As with Ohm's law, any one value can be calculated if the other two are known.

Power = Voltage X Current (1)P = VI or I = P/V or V = P/I

Our VAWT charging system has been represented in Figure 10 as three blocks, i.e. the alternator, battery, and loads. When turbine is not running, the alternator voltage is less than the battery voltage so current flows from the battery to the household loads and the alternator diodes prevent current flowing into the alternator. When engine is running, the alternator output is greater than the battery voltage, so current flows from the alternator to the vehicle loads as well as the battery. This implies that alternator output voltage must always be above the battery voltage during operation of the engine. However, the actual Voltage used is critical and depends on a number of factors.

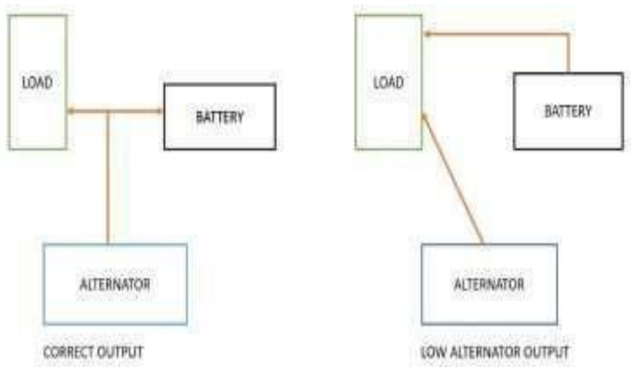


Figure 4.1: Block diagram representing our VAWT charging system.

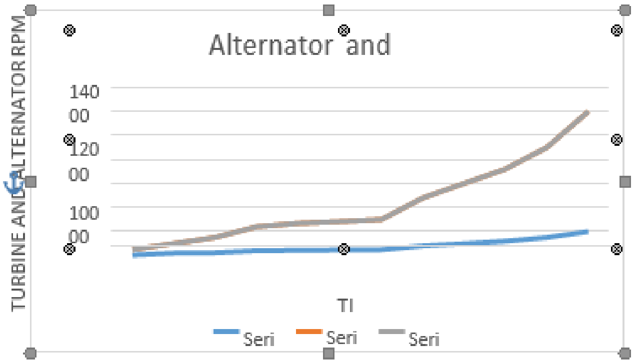
The relationship between alternator speed and alternator current is shown in Figure 15. The current output of the alternator is speed-dependent.

The greater the speed, the greater the output. The rated current is output at an alternator speed of 6000RPM.

Using our Arduino infrared sensor, we were able to measure the revolutions per minute on wind turbine. Using a tachometer, we were able to know the revolutions produced by alternator per second.

Table 4.1: Speed difference between engine and alternator.

Engine speed (RPM)	Alternator speed (RPM)
50	450
200	800
250	1250
400	2000
450	2250
470	2350
500	2500
800	4000
1000	5000
1200	6000
1500	7500
2000	10000



Series 1 is Alternator speed Series 2 is Turbine speed Table 4. 2. Battery Voltages

RPM	VOLTAGE	CURRENT
500	4	65
1000	6	100
5000	7.3	105
8000	8	120

But
Power = Voltage X Current (1)P = VI o

Therefore using multiplication, the various powers produced are

VOLTAGE (V)	CURRENT (I)	POWER (W)
4	35	140
6	50	300
6.5	55	358
6.7	57	382

EFFICIENCY

Efficiency is the state or quality of being efficient.

To get the efficiency, both the actual power generated and theoretical power expected were analyzed

(ACTUAL POWER OUTPUT)/ (THEORITICAL POWER OUTPUT) *100

Actual power was 382 Watts
Theoretical power expected to be produced was 1300 watts

Therefore,

(382)/(1300)*100 =30%

V. CONCLUSION AND RECOMMENDATION

- The efficiency of the fabricated wind turbine was found to be around 30% with variation at different velocities of the wind. This is a very good efficiency compared to horizontal axis wind turbine that has an efficiency of 35%.
- The current VAWTs that are already in the market with different designs have an efficiency of 17%. Though the efficiency seems quite low but it can be seen as usable power generated from nothing. One of the reasons for the low efficiency is that we had much dead weight. These turbines have a great advantage over Horizontal axis wind turbine that they can work on low height thus these turbines can be installed on individual houses for their particular use. The power generated from the turbine can be stored or used to charge a storage device and then the storage device can be used as a continuous power source.
- Having said that there are some limitation of these turbines VAWT blades are rarely at an optimal angle to the wind or in clean air, so they can never be as efficient as a tripled HAWT and won't generate more electricity, HAWTs almost never collapse due to lateral stress, and
- VAWTs typically have very asymmetrical front and rear stresses on their bearings, and to generate the same electricity, VAWTs would have to be as tall as HAWTs, so visual impact will be virtually identical.

Yet with more and more engineers and researchers working on the design and development of Vertical axiswind turbine the efficiency can be increased and the usability of these turbines can be increased.

VI. RECOMMENDATION

- The VAWT should be lifted high enough to maximize wind speed.
- Its blades should be wide to capture good wind speed.
- Dead weight should be reduced.
- A high power alternator should be used to provide more power.

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