An experimental analysis on the performance of a vertical axis wind turbine

A thesis
by

BIKASH SARKER
MD. JAKAREA
MD. RAKIN ABSAR JAHAN
MD. SHAHIN SARKAR
KHADIZA KHATUN

DEPARTMENT OF MECHANICAL ENGINEERING
SONARGAON UNIVERSITY (SU)

FEBRUARY 2020

An experimental analysis on the performance of a vertical axis wind turbine

A Thesis

by

BIKASH SARKER
ID/Reg No.: BME1603010111
Session: 2015-2016

In Cooperation With

MD. JAKAREA
ID/Reg No.: BME1603010036
Session: 2015-2016

MD. RAKIN ABSAR JAHAN
ID/Reg No.: BME1602009125
Session: 2015-2016

MD. SHAHIN SARKAR
ID/Reg No.: BME1602009379
Session: 2015-2016

KHADIZA KHATUN
ID/Reg No.: BME1602009405
Session: 2015-2016

Supervisor: Shahriar Nahian
Lecturer
Department of ME

Submitted to the
DEPARTMENT OF MECHANICAL ENGINEERING
SONARGAON UNIVERSITY (SU)
In partial fulfillment of the requirements for the award of the degree
of
BACHELOR OF SCIENCE IN MECHANICAL ENGINEERING

FEBRUARY 2020

DECLARATION

We do hereby solemnly declare that the work presented in the report has been carried out by us under the supervisor of Shahriar Nahian, lecturer, department of Mechanical Engineering in Sonargaon University. We have tried our best to make the report with accurate information and relevant data.We hereby ensure that, the work that has been presented does not breach any existing copyright.We further undertake to identify the university against any laws or damage arising from breach of the forgoing obligation.We also want to make sure that any single discussion of the study project will not be harmful to other participants. Any mistake or inaccuracies are all of our group members.

Shahriar Nahian

Lecturer

Sonargaon University

Department of ME

(Supervisor's Signature)

……………………………

Signature of candidates

……………..................

Bikash sarker

ID: BME1603010111

………………………..

Md. Jakarea

ID: BME1603010036

....

Md. Rakin Jahan Absan

ID: BME1602009131

………………………

Md. Shahin Sarkar

ID: BME1602009379

………………………...

Kadiza Khatun

ID: BME1602009405

ACKNOWLEDGEMENT

This is to place on record our application and deep gratitude to the faculty members, without whose support this project would have not even seen the light of day. We wish to express our propound sense of gratitude to vice chancellor professor M.A. Razzaque his guidance encouragement, and for all facilities to complete this project. We express our sincere thanks to Md. Mostofa Hossain, head of the department, Mechanical Engineering. We have immense pleasure in compressing our gratitude to our supervisor, Shahriar Nahian, lecturer, department of Mechanical Engineering, for his guidance throughout this project.

ABSTRACT

Wind energy is the most available form of renewable energy among all the energy sources. Wind energy can be extracted by a wind turbine and can be converted into electrical energy using proper electricity generating apparatus. This paper is focused on a technique that can be used effectively for the purpose of converting the kinetic energy of wind into electrical energy. This process is completely friendly to environment and the cost associated with the fabrication is very little. In this research a vertical axis wind turbine has been designed and fabricated to perform the job of extracting energy from wind. The turbine is of Darrieus type with three twisted blades. For the conversion of mechanical energy from the turbine into electric current and alternator also fabricated and coupled with the turbine. This paper describes the whole procedure to build up a simple wind power system with vertical axis wind turbine and shows performance of such power system under various wind speed. The specialty of this system is its extremely simple arrangement and absence of any motion transmission. With the recent surge in fossil fuels prices, demands for cleaner energy sources, and government funding incentives, wind turbines have become a viable technology for power generation. Currently, horizontal axis wind turbines (HAWT) dominate the wind energy market due to their large size and high-power generation characteristics. However, vertical axis wind turbines (VAWT) are capable of producing a lot of power, and offer many advantages over (HAWT). The main objective of this project is to design and build a self-starting vertical axis wind turbine to operate in low wind speed condition. This article presents a vertical axis wind turbine that used residential as a powering source. A VAWT produce electric power from air flow on the blade with shaft rotation. The shaft and generator motor are connected with the pulley to rubber belt. When the shaft starts to rotate, the generator motor and the belt start to rotate. In this case the VAWT used the generator motor to produce electricity. This device consists of a shaft, generator motor, baring, v-belt and other storage battery, rectifier, LED. Height and width of the VAWT 73 cm and 33cm. Also, the blade sheet square 30.48 cm and blew the blade stand length. We are used in this project 50w & 220v ac generator motor. Generator are connected with half wave rectifier to battery. So, if the turbine turned off, the battery will help to back up the power.

TABLE OF CONTENTS

CHAPTER 01

Introduction

1.1 Renewable energy

Wind Turbine Technology is an economical alternative to costly fossil fuel which can be used to generate electricity. There are no adverse effects of wind energy like pollution on environment. Moreover, its installation cost and maintenance cost are very less as compared to other non-renewable energy sources. Modern wind turbine is classified mainly into two types based on position of rotors as Horizontal Axis Wind Turbine (HAWT)and Vertical Axis Wind Turbine (VAWT). Though HAWT are suitable for high wind speed and large-scale power generation, these turbines are uneconomical for small scale power generation. VAWT is the best suitable option which can be explored for further efficiency improvement to make it more suitable for these applications. Also suitable from HAWT for urban areas as they have low noise level and low risk associated with their slower rate of rotation. the main rotor shaft is orientated vertically, when air passes through turbine blade the converted rotational momentum which spins a generator and producing AC current. The generator and the main pulley are located at the base. It can generate power ten time more power in per square meter or square mile from HAWT because of its design. In this project we experiment a savonius type turbine. Wind rotated the 4 blades through the shaft power transmitted to the pulley and pulley drive the generator to produced AC current. Renewable energy sources have more in our country but not produced enough. Now a day, Bangladesh is producing more energy but not from renewable side. In Bangladesh, around 88% [2019] of people having accesses to electricity also about 63% people are living in village. The have some electricity problem and there has some load shedding To combat these situations, renewable energy technology stands out to be one of the prospective sources to meet its unprecedented energy demand and can contribute to achieve sustainable development as a country has a plentiful supply of renewable sources of energy. This paper investigates the prospect, trend, utilization and its technology as well as reviews the policy and institutions and opportunities of renewable energy technology towards.

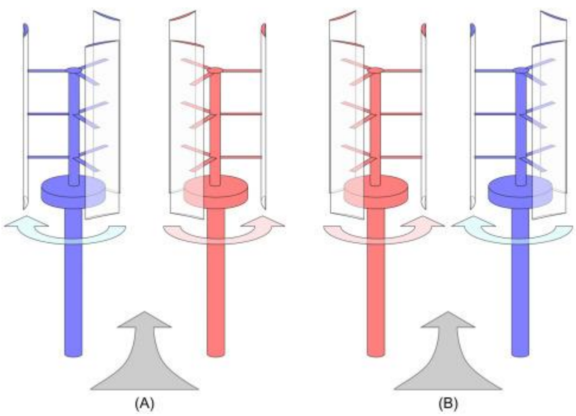

Fig 1.1: Air flow with wind rotation

1.2 Brief history of wind power

The earliest known use of wind power for practical purposes dates to around 5000 years ago when the Ancient Egyptians began to use sails on boats to assist rowing slaves. Over time, Egyptians introduced sail technology in their farming, specifically to assist draft animals in grinding grain and lifting water. This marked the advent of early wind energy conversion systems (Park 1981). Historically, wind energy conversion systems, or WECS, are said to be "one of man's truly basic machines" (Hunt 1981).

The Persians, who are perhaps antiquity's best-known harnessers of the wind, began using wind power around 500 BCE, and by 700 CE had vertical-shaft windmills, or anemones, powering their grain-grinding stones (Park 1981). Reeds were placed across the slats of a wooden frame, which became one of several vertical paddles that spun around a central axis. Walls were built around the apparatus, engineered to ensure the system consistently spun in the desired direction ("Oldest" 2010). Many Middle Eastern civilizations had also appropriated windmill technology by this time. It is often assumed that Crusaders returning to Europe in the 12th and 13th centuries CE brought the concept of the windmill with them, but due to the markedly different design of early European windmills, it is not completely certain whether they were inspired by Middle Eastern genius or developed independently (Park 1981). In any case, it was the Dutch who first came up with the horizontal shaft windmill (the kind most of us probably imagine when we hear „windmill, typically having four sails oriented vertically), and used it to pump water, grind grain and operate sawmills throughout the Medieval Period (Park 1981).

Writing on the use of wind and water mills in this period, Walton (2006) states, "In the pre industrial era (and even for a good portion of the era of modern factory production) mills were everywhere: they ground grain, sawed lumber, filled cloth, pulped paper, pressed cider and olives, and incorporated gunpowder." In 1887, Professor James Blythe of Anderson's College in Glasgow (now Strathclyde University) built the first windmill intended for electricity generation (Nixon 2008). The following is an excerpt from his May 2, 1888 address to the Royal Philosophical Society of Glasgow on his experiment: "In common, I daresay, with many other persons, I have felt, for some time past, that the power of the wind was not sufficiently taken advantage of for the purpose of generating and storing electrical energy; and, in the course of last summer, I determined to make some experiments to test the point in a practical way. These consisted in the erection of a small windmill for supplying electric light by means of storage cells, to a small cottage in the village of Marykirk, Kincardineshire, where I usually spend my summer holiday.

The mill was finished and working about the end of July, 1887. One day last summer, when a good breeze was blowing, I stored as much in half a day as gave me light for four evenings, about three of four hours each time" (Blythe 1888). Across the Atlantic, professor and inventor Charles Brush was not far behind in wind dynamo development in the United States (Nixon 2008). Wind technology played an important role in the development of rural areas of U.S. prior to the 1930s, when the Rural Electrification Act provided farmers with cheap and convenient electricity (Hunt 1981). Back in Europe, Denmark had established enough wind dynamos by World War II to carry the country through the fuel shortage caused by the Nazi occupation (Inglis 1978).

Following the war, the English experimented with a variety of wind dynamo designs and gave serious consideration to increasing the nation's dependence on wind power, eventually choosing nuclear as their major alternative energy source (Inglis 1978). Germany and France also tested innovative wind power technologies, but then-cheap fossil fuels quickly crippled the wind power market (Park 1981).

1.3 Classification of vertical axis wind turbine

Vertical axis wind turbines are advocated as being capable of catching the wind from all directions, and do not need yaw mechanisms, rudders or downwind coning. Their electrical generators can be positioned close to the ground, and hence easily accessible. A disadvantage is that some designs are not self-starting .There have been two distinct types of vertical axis wind turbines: The Darrieus and the Savonius types .The Darrieus rotor was researched and developed extensively by Sandia National Laboratories in the USA in the 1980's. New concepts of vertical axis wind machines are being introduced such as the helical types particularly for use in urban environments where they would be considered safer due to their lower rotational speeds avoiding the risk of blade ejection and since they can catch the wind from all directions .Horizontal axis wind turbines are typically more efficient at converting wind energy into electricity than vertical axis wind turbines .

For this reason, commercial utility-scale wind power market. However, small vertical axis wind turbines are more suited to urban areas as they have a low noise level and because of the reduced risk associated with their slower rates of rotation .One can foresee some future where each human dwelling in the world is equipped with wind generators and solar collectors ,as global peak petroleum is reached making them indispensable for human wellbeing.

They are well suited for green buildings architectural projects as well as futuristic aquaponics where vertical farming in a skyscraper uses automated farming technologies converting urban sewage into agricultural products. Their cost will come down appreciably once they are mass produced on a production line scale equivalent to the automobile industry. The economic development and viable use of horizontal axis wind turbines would, in the future be limited, partly due to the high stress loads on the large blades. It is recognized that, although less efficient, vertical axis wind turbines do not suffer so much from the constantly varying gravitational loads that limit the size of horizontal axis turbines.

The first aerodynamic vertical axis wind turbine was developed by Georges Darrieus in France and first patented in 1927. Its principle of operation depends on the fact that its blade speed is a multiple of the wind speed, resulting in an apparent wind throughout the whole revolution coming in as a head wind with only a limited variation in angle. Cyclists will recognize that effect if they go fast enough there is always a head wind.

From the perspective of the blade, the rotational movement of the blade generates a head wind that combines with the actual wind to form the apparent wind. If the angle of attack of this apparent wind on the blade is larger than zero, the lift force has a forward component that propels the turbine. A Darrieus turbine cannot be self-starting it needs to be brought to a sufficiently high blade speed by external means. The original Darrieus turbine suffered from some negative features such as violent vibrations leading to eventual fatigue blade failure, a high noise level and a relatively low efficiency, which severely limited its success.

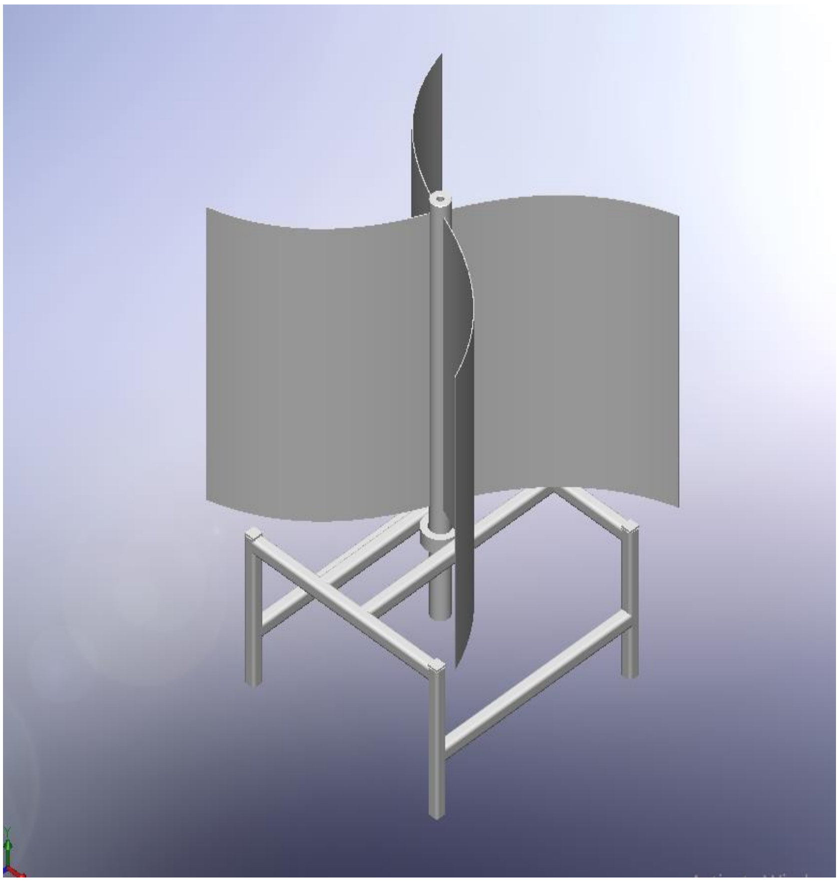

Fig 1.2: Vertical axis wind turbine.

1.4 Wind power generation scenario in Bangladesh

Bangladesh is encountering difficulties in supplying energy to maintain its economic growth. Government of Bangladesh is looking for renewable energy sources to meet up the total power demand in this country. The present study aims to assess wind energy potential in Bangladesh as a sustainable solution to overcome the energy crisis. Wind speed at six coastal zones Patenga, Cox's Bazar, Teknaf, Char Fassion, Kuakata and Kutubdia at Bay of Bengal of Bangladesh have been analyzed. A near shore wind farm has been considered at these locations having a coastal line of 574 km. The turbines are spaced 7D apart in the prevailing wind direction, and 3D apart in the perpendicular direction, where D is rotor diameter. This near shore wind farm with an array of 5104 horizontal axis wind turbines with hub height of 100 m and rotor diameter of 75 m with a wind speed of 7 m/sec is capable to generate 1855.25 MW of electrical power. This can mitigate 55.93 per cent of energy shortage in 2016. By developing renewable energy sources, it is possible to compensate 11.25 per cent of total power demand by 2020.Wind resource assessment is the process of estimating the wind resource or wind power potential at one or several sites or over an area. One common result of the assessment could be a wind resource map.

The wind resource map usually shows the variation over an area of the mean wind speed or power density for a given height above ground level. While this may provide an indication of the magnitude of the wind resource, a more realistic estimate is obtained when the sector-wise wind speed distributions are combined with the power curve of a given wind turbine to obtain a power production.

The result of wind resource assessment is therefore an estimate of the mean wind climate at one or a number of sites, in the form of the: • Wind direction probability distribution (wind rose), which shows the frequency distribution of wind directions at the site, i.e. where the wind comes from, • Sector-wise wind speed probability distributions, which show the frequency distribution of wind speeds at the site. Wind resource assessment provides one important input for the siting, sizing and detailed design of the wind farm and these inputs are exactly what the WAsP software provides. When it comes to the siting of individual wind turbines, a site assessment (IEC 61400-1) is usually carried out. This will provide estimates for each wind turbine site of the 50year extreme wind, shear of vertical wind profile, flow and terrain inclination angles, free-stream turbulence, wind speed probability distribution and added wake turbulence. This additional information may be obtained by using the WAsP Engineering software. Observation-based wind resource assessment Conventionally, wind resource assessment and wind farm calculations are based on wind data measured at or nearby the wind farm site. Wind power is the conversion of wind energy by wind turbines into a useful form, such as electricity or mechanical energy. The power is directly proportional to the velocity of the wind. Large scale wind farms are connected to the local power transmission network with small turbines used to provide electricity to isolated areas. Bangladesh is in the midst of a severe energy and power supply crisis, one of the worst in South Asia. Bangladesh has a 724km long coastline and many small islands in the Bay of Bengal, where strong southwesterly trade wind and sea-breeze blow in the summer months and there is a gentle northeasterly trade wind and land breeze in winter months [11]. Along the coastal area of Bangladesh, the annual average wind speed at 30m height is more than 5 m/s [10]. Wind speed in northeastern parts in Bangladesh is above 4.5 m/s while for the other parts of the country wind speed is around 3.5 m/s [10,12].

type wind turbines are being installed. The total capacity of all the wind turbines being stored in a battery bank. WBHPP was officially started on March 30,2008[14]. In another project, Bangladesh power development board (BPDB) has implemented a 0.90MW capacity of the grid connected wind energy (GCWE) at the Muhuri Dam areas in the Feni district in 2004. This is the first ever GCWE project in Bangladesh. Thus, generating electricity from wind in the coastal areas can be transmitted to other regions of the country through the high voltage transmission lines. Very little operation and maintenance will be required during the whole life time of wind turbines and no fuel will be required for generating electricity from wind [15].

1.5 Objective.

The main objective of the thesis is to design, fabrication and assess the performance:

- ❑ To provide for testing, analysis and optimization.
- ❑ To achieve a cost effective and versatile method of harnessing wind energy.
- ❑ To achieve the turbines power output needed to be maximized while simultaneously minimizing the cost of the turbine.
- ❑ To determine ways in which cost of production can be cut without significant loss in performance.
- ❑ To increase awareness of the negative environmental impacts of non-renewable energy sources has lead to an increased demand for renewable energy technologies.

CHAPTER 02

LITERATURE REVIEW

Bangladesh is a developing country; it has probability to progress towards increasing the demand of energy. Now a day, Bangladesh is facing energy crisis. In Bangladesh, around 70% of people having lack accesses to electricity and most of them are living in the village. Among them about 40% of them are living in below poverty line. On the other hand, climate change puts addition threats to development. To combat these situations, renewable energy technology stands out to be one of the prospective sources to meet its unprecedented energy demand and can contribute to achieve sustainable development as a country has a plentiful supply of renewable sources of energy. This paper investigates the prospect, trend, utilization and its technology as well as reviews the policy and institutions and opportunities of renewable energy technology towards sustainable development and climate change mitigation is context of Bangladesh. Rapid increase in global energy requirements has resulted in considerable attention towards energy generation from the renewable energy sources. In order to meet renewable energy targets, harnessing energy from all available resources including those from urban environment is required. Vertical Axis Wind Turbines (VAWTs) are seen as a potential way of utilizing urban energy sources. Most of the research on the wind turbines constitutes condition monitoring and performance optimization of VAWTs under a constant velocity of air where the transient effects have not been accounted. The inconsistent behavior of the wind may change the nature of the flow field around the VAWT which could decrease its life cycle. This study is an attempt to use Computational Fluid Dynamic's techniques to study and analysis the performance of a wind turbine under accelerating and decelerating air inlet velocity. The performance of a VAWT is monitored under an accelerated and decelerated gust of the value $1.09m/s^2$ characterized by change in velocity from 4m/sec to 10m/sec. The instantaneous torque output varies significantly when a gust of air is applied to the turbine. Furthermore, the torque outputs during accelerating and decelerating flows vary, highlighting the effect of transient phenomena. This abrupt change in the instantaneous torque output of the turbine may give rise to highly transient loads on the turbine's structure which may induce heavy stresses on the turbine leading to structural failure. It has been shown that CFD can be used as an effective tool to predict the performance outputs of a VAWT under varying flow conditions.

Renewable energy plays a significant role in overcoming the increased energy demand. Considerable amount of research has been carried out in renewable energy sector, mainly wind energy. Wind energy has a great potential to overcome excessive dependence on fossil fuels to meet energy demand. The wind turbine systems can be classified the vertical axis wind turbine (VAWT) based upon the direction of the axis of rotation. When the wind stream is parallel to the rotational axis of turbine rotor. Similarly, when the wind direction is perpendicular to the rotational axis of turbine rotor, it is referred to as VAWT. The performance capabilities of the wind turbines depend greatly on the torque output which further depends upon the torque generating capability of the rotor. VAWT but require good quality wind energy. In urban areas where wind is in-consistent and highly fluctuating, VAWT is more beneficial due to its low starting torque characteristics as well as other advantages like being in-expensive to build and of simple design. The important performance parameters of VAWTs, as mentioned by Colley et al are the tip speed ratio (TSR) and the torque output. TSR is the ratio between the rotational speed of the tip of the blade and the actual velocity.

Vertical Axis Wind Turbine (VAWT) is relatively simple to implement in urban areas on ground or/and building-roofs, the development of appropriate design of VAWT will open new opportunities for the large-scale acceptance of these machines. The primary objective of this research was to design and modeling of a small-scale VAWT, which can be used to meet the power for low demand applications. MATLAB simulation was utilized to develop a mathematical model, which comprised of wind power coefficient, tip speed ratio, mechanical and electrical subcomponents. The measured results of developed turbine were used for the validation of the model. The aims were to analyze the turbine blade shapes, develop a mathematical algorithm, and to establish the techno economic performance of the new curved shape design.

Vertical axis wind turbines are currently experiencing a renewed interest in small scale applications, often driven by their low noise levels, and sometimes by their ability to handle the “dirty” wind seen in urban environments. However, vibration is a large issue with VAWTs due to their highly variable blade loadings as the turbine rotates. One technique to reduce vibration is to reduce the turbine rotational speed by increasing the solidity of the turbine. Higher solidities lead to complex aerodynamics involving vortex shedding and continuing interaction between shed vortices and their originating blades. The power efficiencies of such flows are less than the simpler flows seen in low solidity turbines.

Studies of climate change typically consider measurements or predictions of temperature over extended periods of time. Climate, however, is much more than temperature. Over the oceans, changes in wind speed and the surface gravity waves generated by such winds play an important role. We used a 23-year database of calibrated and validated satellite altimeter measurements to investigate global changes in oceanic wind speed and wave height over this period. We find a general global trend of increasing values of wind speed and, to a lesser degree, wave height, over this period. The rate of increase is greater for extreme events as compared to the mean condition.

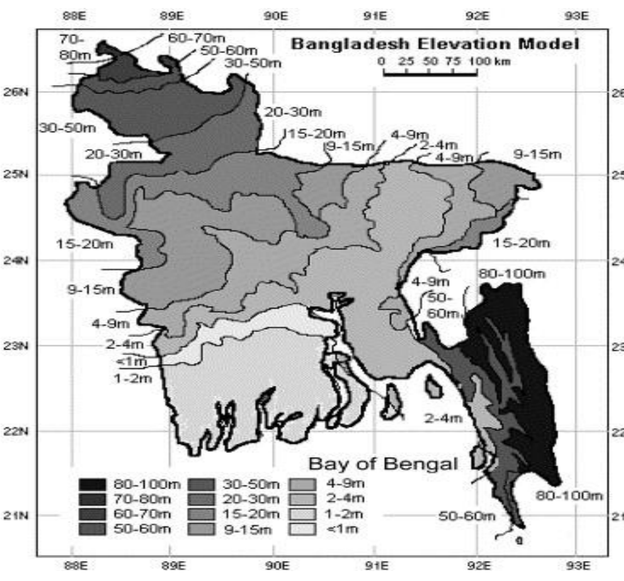

Fig 2.1: Wind speed in Bangladesh.

There is an air turbine of large blades attached on the top of a supporting tower of sufficient height. When wind strikes on the turbine blades, the turbine rotates due to the design and alignment of rotor blades. The shaft of the turbine is coupled with an electrical generator. The output of the generator is collected through electric power cables.

When the wind strikes the rotor blades, blades start rotating. The turbine rotor is connected to a high-speed gearbox. Gearbox transforms the rotor rotation from low speed to high speed. The high-speed shaft from the gearbox is coupled with the rotor of the generator and hence the electrical generator runs at a higher speed. An exciter is needed to give the required excitation to the magnetic coil of the generator field system so that it can generate the required electricity. The generated voltage at output terminals of the alternator is proportional to both the speed and field flux of the alternator. The speed is governed by wind power which is out of control. Hence to maintain uniformity of the output power from the alternator, excitation must be controlled according to the availability of natural wind power. The exciter current is controlled by a turbine controller which senses the wind speed. Then output voltage of electrical generator(alternator) is given to a rectifier where the alternator output gets rectified to DC. Then this rectified DC output is given to line converter unit to convert it into stabilized AC output which is ultimately fed to either electrical transmission network or transmission grid with the help of step up transformer. An extra unit is used to give the power to internal auxiliaries of wind turbine (like motor, battery etc.), this is called Internal Supply Unit.

Wind characteristics and wind turbine characteristics in Taiwan have been thoughtfully analyzed based on a long-term measured data source (1961–1999) of hourly mean wind speed at 25 meteorological stations across Taiwan. A two-stage procedure for estimating wind resource is proposed. The yearly wind speed distribution and wind power density for the entire Taiwan is firstly evaluated to provide annually spatial mean information of wind energy potential. A mathematical formulation using a two-parameter Weibull wind speed distribution is further established to estimate the wind energy generated by an ideal turbine and the monthly actual wind energy generated by a wind turbine operated at cubic relation of power between cut-in and rated wind speed and constant power between rated and cut-out wind speed. Three types of wind turbine characteristics (the availability factor, the capacity factor and the wind turbine efficiency) are emphasized. The monthly wind characteristics and monthly wind turbine characteristics for four meteorological stations with high winds are investigated and compared with each other as well. The results show the general availability of wind energy potential across Taiwan.

Wind turbine characteristics for various wind turbine generators by using the same sets of wind data at Kappadgudda wind power station, India. The above studies either investigated wind characteristics (wind speed and wind energy density) only, or focused on part of wind turbine characteristics of a given wind turbine generator such as the capacity factor. For example, for a very large rotor together with a very small generator, a wind turbine would run at full capacity and thus achieve a very high capacity factor. But it could produce very little electricity, resulting in low wind turbine efficiency. In such a situation, considering only the capacity factor cannot provide overall information on wind turbine characteristics. To understand in depth wind turbine characteristics of a given generator for different locations, three types of wind turbine characteristics (the availability factor, the capacity factor and the wind turbine efficiency of a chosen wind turbine) are addressed and investigated. A two-stage procedure for estimating wind resources in Taiwan is firstly evaluated. The monthly wind speed distributions, wind power densities, and aforementioned wind turbine characteristics are next studied and used to map out the general availability of wind energy potential across Taiwan.

Matrix converter (MC) is a one-stage AC/AC converter that is composed of an array of nine bidirectional semiconductor switches, connecting each phase of the input to each phase of the output. The basic idea behind matrix converter is that a desired output frequency, output voltage and input displacement angle can be obtained by properly operating the switches that connect the output terminals of the converter to its input terminals. The development of MC configuration with high-frequency control was first introduced in the work of Venturina and Alesina in 1980. They presented a static frequency changer with nine bidirectional switches arranged as a 3×3 array and named it a matrix converter. They also explained the low-frequency modulation method and direct transfer function approach through a precise mathematical analysis. In this method, known as direct method, the output voltages are obtained from multiplication of the modulation transfer matrix by input voltages. Since then, the research on the MC has concentrated on implementation of bidirectional switches, as well as modulation techniques.

One of practical problems in the implementation of MC is the use of four-quadrant bidirectional switches. Using this type of switch is necessary for successful operation of MC. The earlier works applied thyristors with external forced commutation circuits to implement the bidirectional controlled switch but this solution was bulky and its performance was poor. Monolithic four-quadrant switches are not available to date. However, the introduction of power transistors provided the possibility of implementing four-quadrant switches by anti-parallel connection of two two-quadrant switches. Another problem in implementing MC is the switch commutation problem that produces over-current, due to short circuiting of the ac sources, or over-voltage spikes, due to open circuiting the inductive loads, that can destroy the power semiconductor. Safe commutation has been achieved by the development of several multi-step commutation strategies and the “semi-soft current commutation”
Presented the environmental impacts and socio-economic effects of petroleum production largely on the basis of national examples. The question is whether the results from this country analysis are representative of petroleum production as a whole. The countries studied within the framework of this study represent a relatively small portion of global petroleum production. The list of unanalyzed impacts also shows that the consequences of petroleum production go far beyond the results of this study. It is also to be expected that the negative environmental impacts and socio-economic effects of conventional and unconventional fossil fuels will continue to increase in the future: Africa’s significance for global petroleum production is growing while the problems of the existing petroleum-producing countries have not been solved and further politically unstable petroleum-producing countries are being added. Tar sand mining and the production of extra heavy oil will continue to increase. Without the creation of alternatives, fuels from oil shale and coal will be added, with considerable environmental effects.

CHAPTER 3

Methodology

3.1 Savonius wind turbine

This paper presents a review on the performance of Savonius wind turbines. This type of turbine is unusual and its application for obtaining useful energy from air stream is an alternative to the use of conventional wind turbines. Simple construction, high startup and full operation moment, wind acceptance from any direction, low noise and angular velocity in operation, reducing wear on moving parts, are some advantages of using this type of machine. Over the years, numerous adaptations for this device were proposed. The variety of possible configurations of the rotor is another advantage in using such machine. Each different arrangement of Savonius rotor affects its performance.

Fig 3.1: Savonius wind turbine with 4 blades

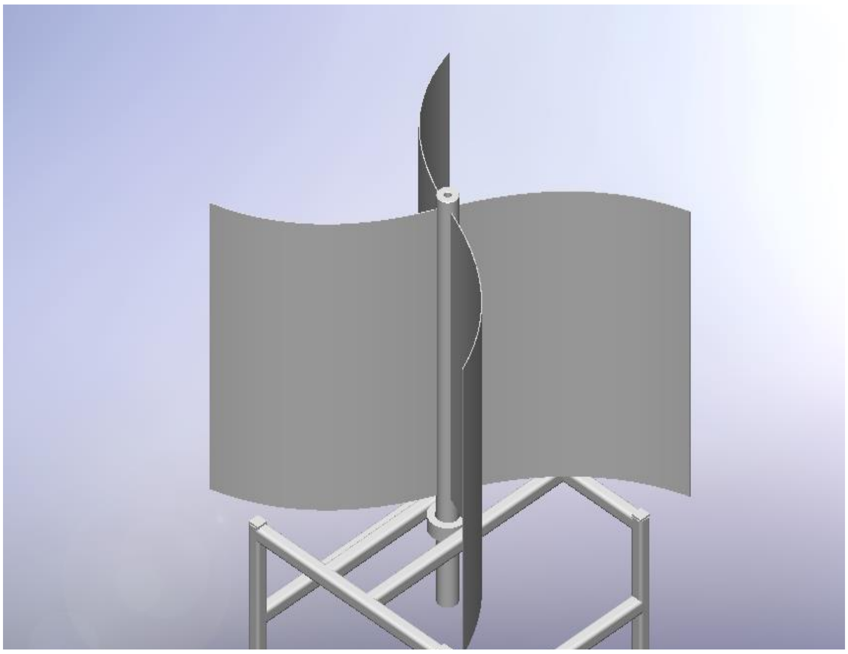

Fig 3.2: Savonius wind turbine with Solidwork Design

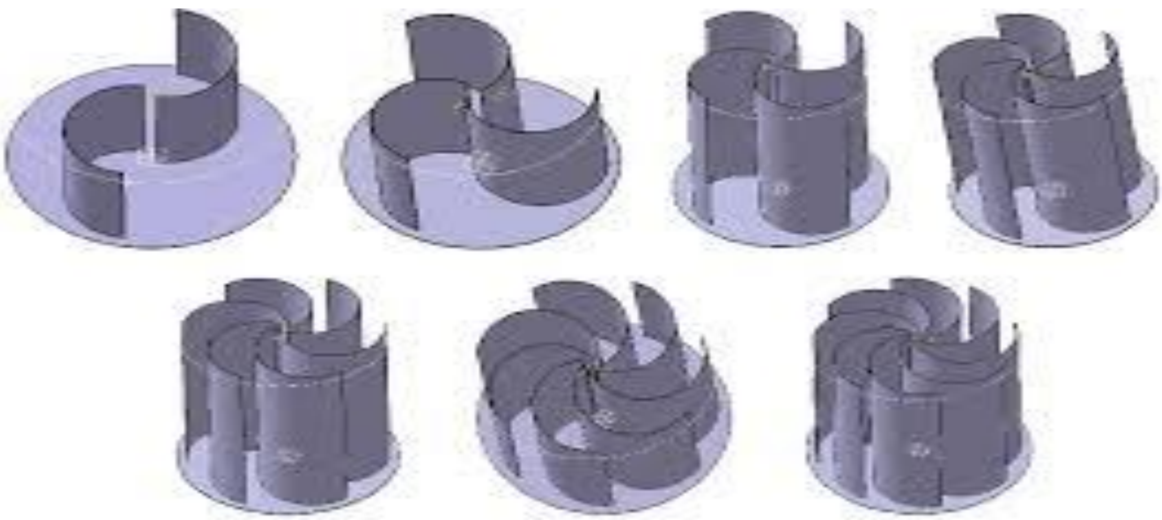

Fig 3.3: Savonius wind turbine different blade

Savonius rotor performance is affected by operational conditions, geometric and air flow parameters. The range of reported values for maximum averaged power coefficient includes values around 0.05–0.30 for most settings. Performance gains of up to 50% for tip speed ratio of maximum averaged power coefficient are also reported with the use of stators. Present article aims to gather relevant information about Savonius turbines, bringing a discussion about their performance. It is intended to provide useful knowledge for future studies.

Fig 3.4: Small 4 blade Savonius wind turbine

Following the discovery of fire, biomass became the main source of energy used by mankind. Advanced societies have largely replaced the use of biomass with the use of fossil fuels, but our dependence on these ever-scarcer resources, plus the need to reduce CO_2 emissions in the face of climate change, is forcing us to make use of renewable sources of energy, including biomass. The exploitation of this resource often requires that its heating value be known. This can be determined either directly (though not cheaply) or by the use of models that predict it using a number of easily and economically determined variables. The present review gathers together the most recent models for predicting the heating value of biomass, assesses their areas of application, and highlights errors that have been made in their formulation, transcription, and in the references made to them.

A Savonius vertical-axis wind turbine is a slow rotating, high torque machine with two or more scoops and are used in high-reliability low-efficiency power turbines. Most wind turbines use lift generated by airfoil-shaped blades to drive a rotor, the Savonius uses drag and therefore cannot rotate faster than the approaching wind speed. Now let’s take a look at the second type, which is also the most popular of the two. The Savonius wind turbine is the most popular of the two types. Let’s go ahead and look at some of the features these VAWT offer to the homeowner. Different models have relied upon elemental, proximal, structural, physical and chemical analyses to determine the values of necessary variables, although those relying on the results of the first two types of analysis have been the most popular. The frequency with which important information has been left unconsidered in some studies, which has led to errors in the expressions presented, as well as errors of transcription and referencing, suggest that future work should be undertaken with greater diligence. In reducing the global dependency on fossil_fuels, rice_husk and rice straw which are the widely abundant agricultural wastes from the rice industry have a vital role to play. This paper also describes the various chemical and physical_pretreatment techniques that can facilitate handling and transportation of rice straw and husk. Finally, the paper presents the state-of-the-art on thermo-chemical and bio-chemical technologies to convert rice husk and rice straw into energy.

3.2 Joining between shaft and rotor

V belt plastic pulley joining method of a rotor shaft with a belt was developed to produce automobiles axle parts. In this process, a high strength shaft with plastic pulley was indented into the hole of a thick .The shaft height 51.2cm with blade 73.5cm and shaft diameter 1.7 cm .Shaft pulley has two changing option its diameter 4cm-2cm and generator pulley also has two changing option diameter 2cm-4cm .The serrated shaft acts as a tool to indent to the hole. Since the v belt with the pulley-shaped hole strengthened with the motor pulley, the yielding strength of the join was one times as high as that of a joint produced by metal cutting. Those conditions and mechanism were experimentally determined. In order to ensure full-surface thrust contact and coverage despite a low.

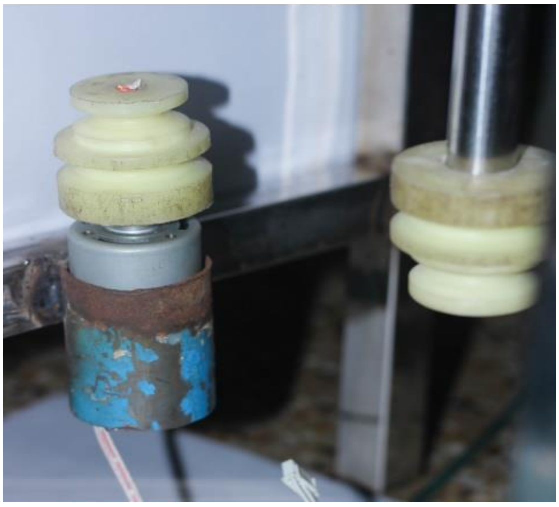

Fig 3.5: Pulley setting with shaft and generator

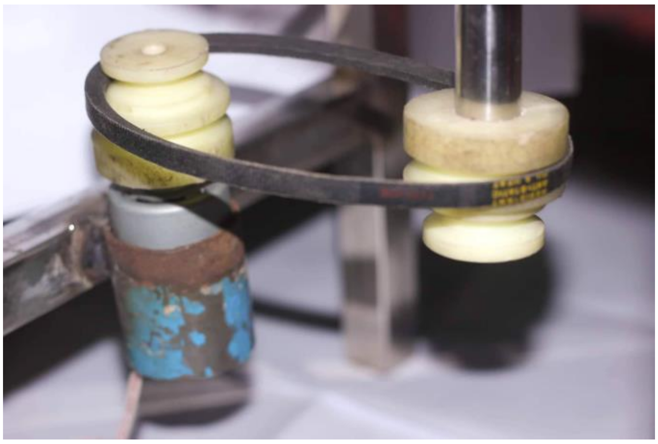

Fig 3.6: Two pulley are connected with v belt

Production and assembly outlay, even if the bearing is mounted slightly askew, a thrust and cover washer may be used which includes an inelastic first annular washer part axially thrusting and not contacting the rotor shaft, and an elastic second annular washer part positively joined thereto and resting sparingly on the rotor shaft. The first annular washer part may advantageously be made of plastic and the second annular washer part may advantageously be made of an elastomeric.

3.3 Pulley

In a plastic v belt pulley support structure of a turbine shaft in which a plastic v belt pulley is supported by a holed shaft member and a v belt pulley supporting member, Shaft pulley and generator pulley diameter 4cm and 2cm respectively connected with a belt distance 4.5cm. A groove is formed on an end surface of the holed shaft member, wherein the holed shaft member and the plastic pulley supporting member are coupled together by inserting a connecting edge, which is formed by plastically deforming an inner peripheral edge of a hole formed in the guide pulley supporting member, into the groove.

Fig 3.7: Shaft and generator motor pulley

3.4 Belt drive

A v belt pulley arranged on a shaft and to transmit rotation from electrical generator pulley. The v belt pulley connected with a small pulley on electric generator. The main shaft and generator are connected with rubber v belt; wherein the fast shafts are in turn rotationally connected to the single electrical generator. The shaft pulley and generator pulley between distance 4.5 cm. The shaft and generator pulley is 1:2, that's mean when the shaft will rotated 1rpm generator will spin 2 rpm.

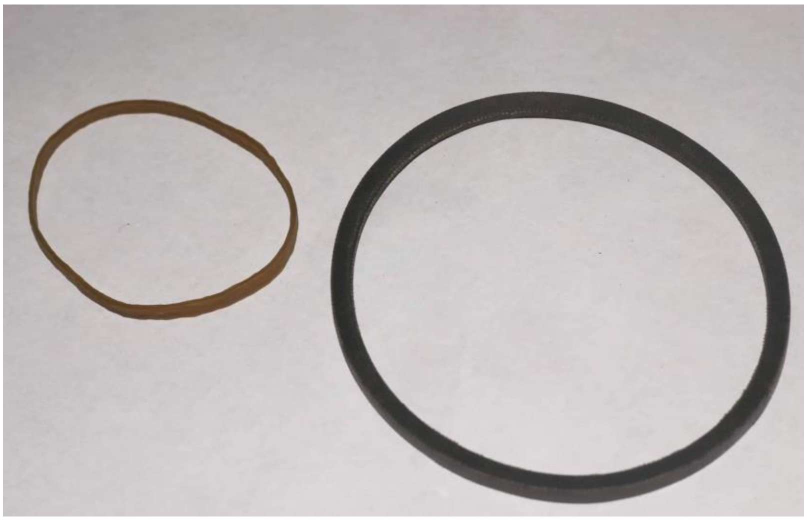

Fig 3.8: V and Rubber belt

3.5 Battery

An improved wind turbine device with energy storage comprises a turbine rotor with rotatable vertical shaft, at least one bearing for said vertical shaft, and rotor vanes disposed symmetrically for rotation about the vertical shaft. Each of said flaps is capable of moving with the directional passage of wind through the vane. Battery is the most important part of energy storage. Here we using 600mAh 3.4v battery. This is a backup storage, when the air flow will low but power is needed, that time we can use the storage capacity.

Fig 3.9: Battery (6v)

Chapter 4

Result and Discussion

4.1 Air velocity measurement

A small size figure,12 in length by 12 in high Vertical Axis Wind Turbine (VAWT) consisting of four sheet metal blades, each with a span of 30 in and a chord length of 10 in, was tested in an open-air wind tunnel facility to investigate the effects of preset toe-in and toe-out turbine blade pitch.

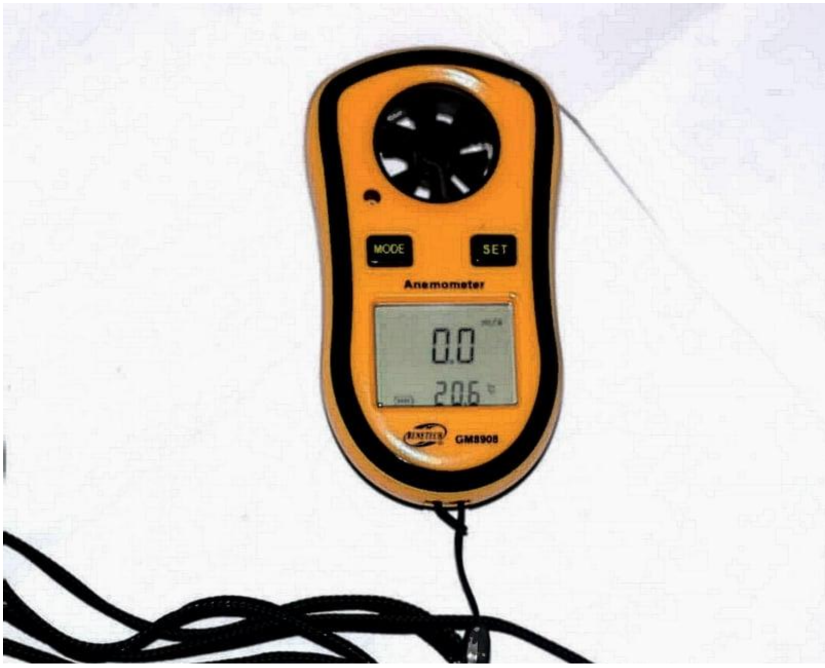

Fig 4.1: Air velocity measure device anemometer

We measure air velocity with anemometer. The effect of blade mount-point offset was also investigated. The results from these tests are presented for a range of tip speed ratios, and compared with an extensive base data set obtained for a nominal wind speed of 7 m/s and air velocity is 3.6 m/s is lower. When the velocity is increases any other option the power output is given different. Also, blade mount-point offset tests indicate decreases in performance as the mount location is moved from mid-chord towards the leading edge, as a result of an inherent to in condition. Observations indicate that these performance decreases may be minimized by compensating for the blade mount offset with a toe-out preset pitch. The trends of the preset blade pitch tests agree with those found in literature for much lower solidity turbines.

4.2 Shaft rotation per minute

Every vertical axis wind turbine is a different types of shaft rotation speed, if blade haven't same .After our all experimental analysis complete we got, our shaft rotation speed 57rpm,is the lower energy produced .Its mean if the shaft rotation rate in minute less than 57rpm ,our VAWT will not produce power or energy .Show below the shaft rotation fig,

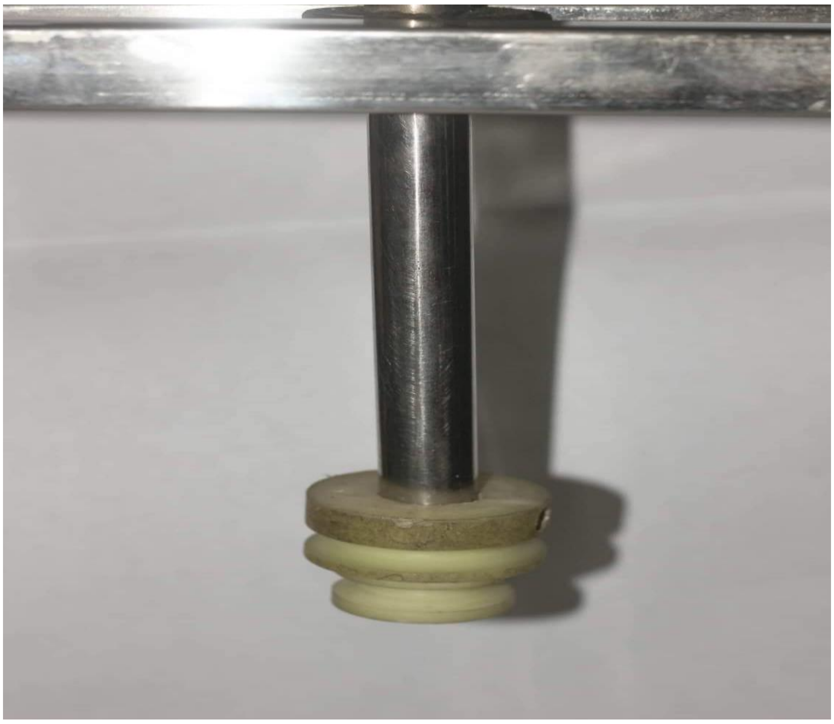

Fig 4.2: Shaft with pulley

4.3 Generator RPM measurement

A tachometer (revolution-counter, teach, reencounter, RPM gauge) is an instrument measuring the rotation speed of a shaft or disk, as in a motor or other machine the device usually displays the revolutions per minute (RPM)on a calibrated analoguedil, but digital displays are increasingly common. Essentially the words tachometer and speedometer have identical meaning a device that me a surest speed.it is by arbitrary convention that in the automotive world on the used for engine and other for vehicle speed. 50w 220v AC generator motor has been taken as a motor in our VAWT with a 73.6cm. Here the size of the motor is L 75 mm and D 25 mm .The motor is capable of producing 220v energy as output, if it can be rotated 1500rpm.the motor is connected to a shaft by a belt .It has a pulley attached to it .As the velocity of the battery increases the output and output of the motor. The output and input are shown below the curve.

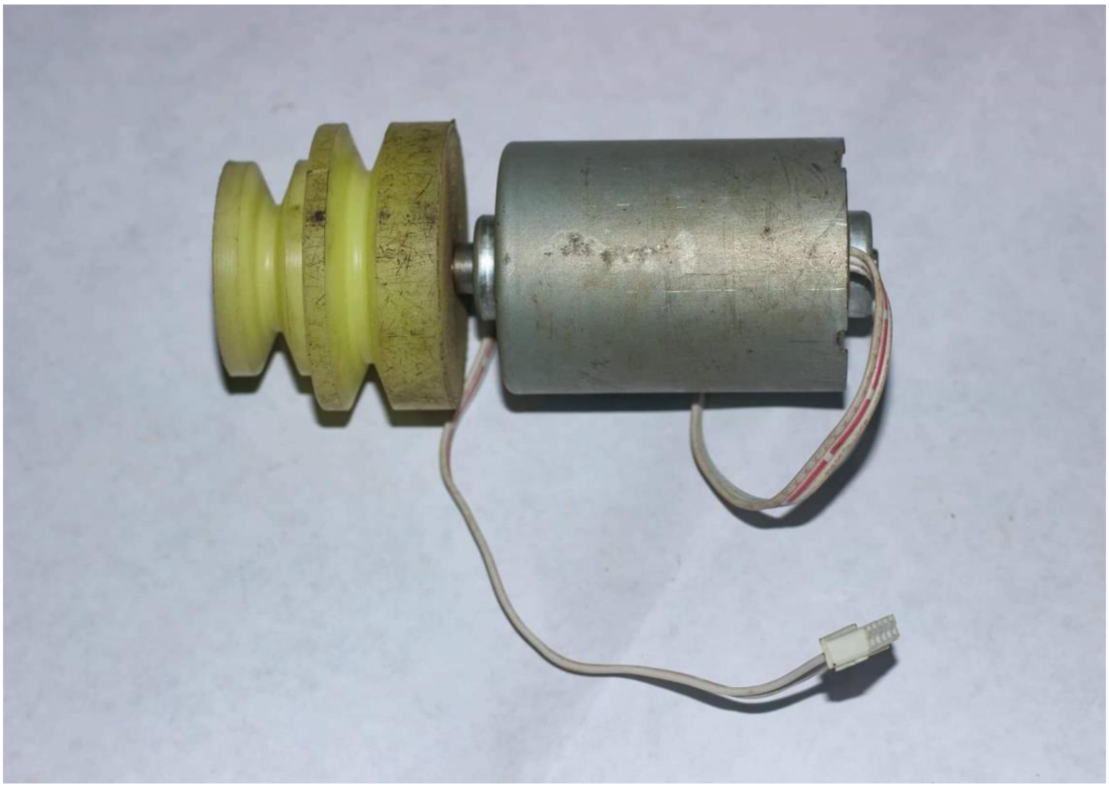

Fig 4.3: Generator motor

4.4 power output ACV

Small size wind turbines can be attractive from many points of view: the environmental impact is low; they do not cause instabilities in the power network distribution and they do not need large power storage capabilities. Nevertheless, the exploitation of small turbines usually faces with several shortcomings and the actual return is often lower than expected, mainly because the power curve given by the manufacturer usually does not reproduce the actual behavior of the turbines during the operating conditions.

Using high-resolution wind speed and energy production measurements, this paper presents an in situ experimental analysis of two small size wind turbines with the same rated power, placed in the same urban environment and realized with vertical and horizontal axis, respectively. Wind conditions are particularly interesting as they are characterized by two distinct regimes, corresponding to low (wind blowing from the sea) and high turbulence (wind blowing from the land).

The detected power production is discussed, showing the mutual strengths and weaknesses of the two technologies, focusing on the role of the technical features and control apparatus on the one hand and of the incoming wind conditions and turbulence on the other.

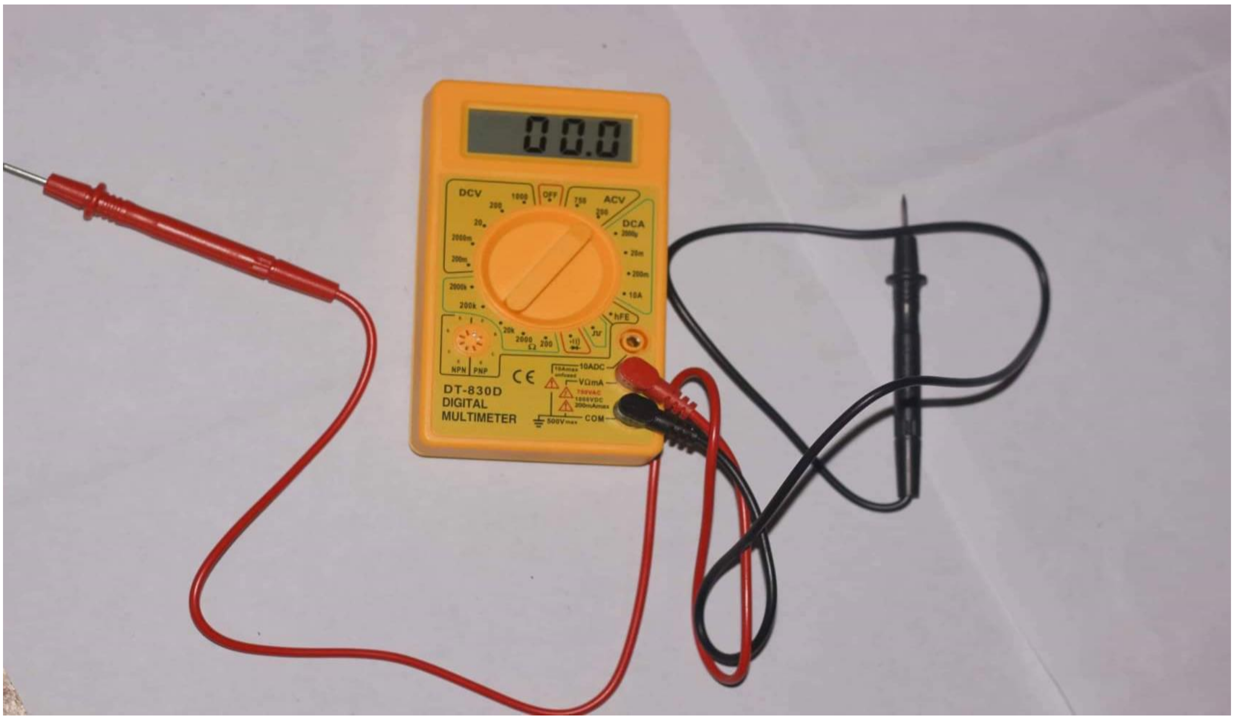

Fig 4.4: Digital Multimeter

We got from our experimental analysis is good performance, its power increases with air velocity. When the air velocity is 3.5m/s, it’s going to work. If air velocity will down this flow, it will be not working.

4.5 Energy uses application

The goal of this study is to investigate the effect of various design parameters on the performance of a Vertical Axis Wind Turbine (VAWT) subjected to realistic unsteady wind conditions. Thirteen turbine design configurations are examined to determine if an optimal VAWT has applications in an urban/suburban environment. The four design parameters of interest include the height-to-diameter aspect ratio (0.83≤H/D≤1.340.83≤H/D≤1.34), blade airfoil shape (NACA 0012, 0015, 0018), turbine solidity (12≤S≤25%12≤S≤25%), and turbine moment of inertia. The height and diameter of the turbine varied between 1.89 and 2.54 m, depending on the aspect ratio. The turbine moment of inertia was calculated using a computer-aided design drawing of the turbine, along with the realistic material properties of blades, shafts, and supports. The energy generated by each VAWT design configuration is simulated using a full year of actual wind speed data collected in 2009 at 9 different locations around Oklahoma City spanning an area of approximately 500 km^2. The wind data were acquired from the top of traffic light posts at a height of about 9 m above the ground. In all cases, an active control strategy is used that allows the turbine to continuously adjust its rotational speed in response to the fluctuating wind. The results suggest that, for the case of operation in unsteady winds, the optimal power coefficient (C_p) versus tip speed ratio curve is not necessarily the one exhibiting the highest peak C_p value but rather the broadest shape. Of the thirteen configurations examined, the optimal wind turbine design capable of harvesting the most energy from the gusty winds was found to have an aspect ratio of H/D=1.2H/D=1.2, a solidity of S=12%S=12%, and a blade shape using the NACA 0015 airfoil. This design also displayed the lowest moment of inertia. However, when the effects of mass were removed, this design still performed the best.

Fig 4.5: Savonius wind turbine energy using at home

The site-to-site variation in terms of energy captured relative to the available energy in the gusty winds was only about 5% on average and increased slightly with turbine moment of inertia. Four of the suburban sites studied were deemed to be economically viable locations for a small-scale VAWT. The results further indicate that, at one of these sites, the levelized cost of energy associated with the top performing turbine designs examined in the study was about 10% less than the national electricity price, meaning that wind energy provides a cheaper alternative to fossil fuel at this location. It is surmised that VAWTs could economically harvest wind energy in the urban center as well if the turbines were located higher than 9 m, such as on the rooftops of commercial/residential buildings.

Fig 4.6: Energy storage & usage with LED

4.6 Air Velocity

The airfoil design we have used able to spin the generator under load with or without the enclosure. Even though we tested at speeds 30 to 65 rpm around many different options, this design remained successful. This design proved to be an efficient design for the vertical axis wind turbine. Below show the air velocity and shaft rpm table and curve. This curve represents the air velocity compare with the shaft rotation per minute.

Air velocity (m/s)	Ac volt
3.6	1
4.1	2.3
4.6	3.1
5.1	3.75
5.6	4.79
6.1	6.01
7.0	8.09

Table 4.7: Air velocity and AC volt

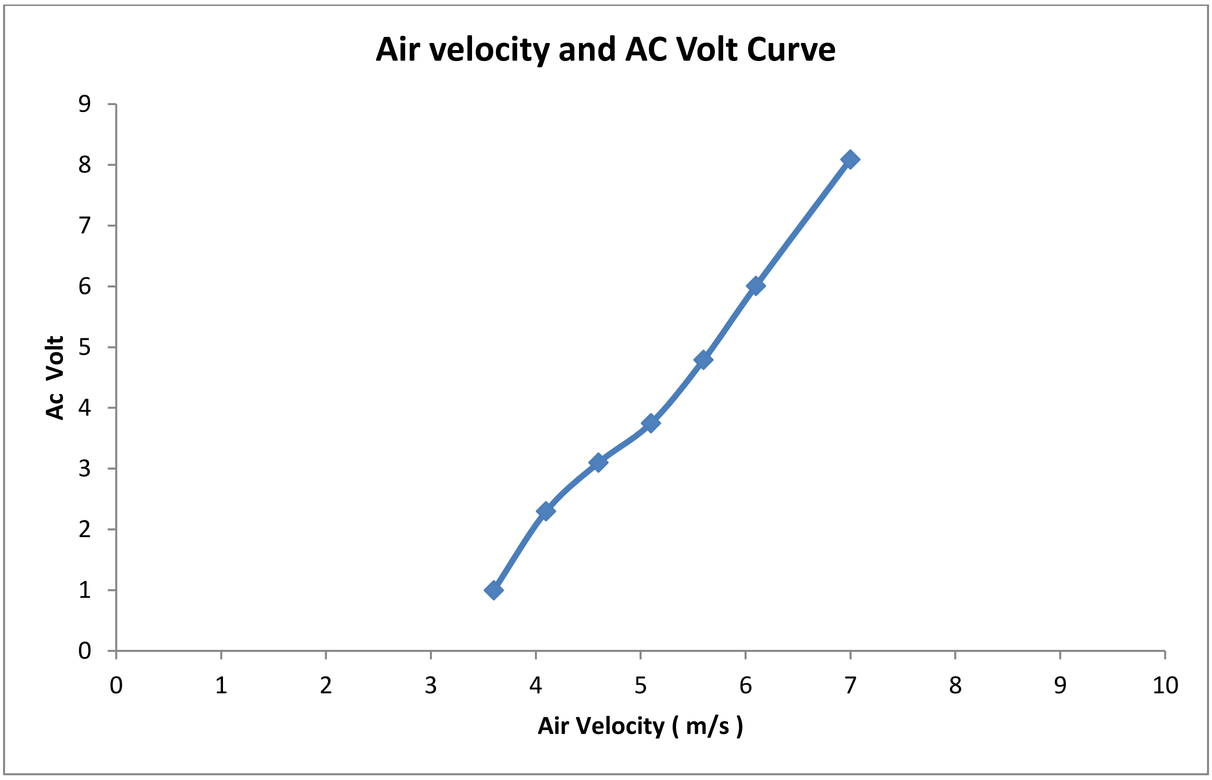

Fig 4.7: Air velocity and Ac Volt curve

Chapter 5

Conclusion

The principal goal of this project was to test the performance of an innovative design of a Savonius Vertical Axis Wind Turbine proposed by a home used based startup. In order to do so, we first designed this project on Solid Works. It generated high pressure farther from the axis compared to the barrel design, and hence generated a lower torque. In order to further test these designs, we built simplified models using readily available materials. Using a makeshift wind tunnel, and commercial fans, we tested the two designs under three different wind speeds. Through angular velocity, acceleration measurements, and numerically calculated moment of inertia, we determined the torque generated by the different designs and calculated their power coefficient. This means that there are many questions about Savonius and other types of VAWTs that are worth researching. Variables such as overlap, curvature of the blades, orientation, etc. need to be investigated in order to better understand these designs. In the end, we would like to mention that this was an amazing learning journey. We hope that this will serve as the first step towards establishing a hands-on and fabrication tradition in the School of Science and Engineering. Throughout the different phases, we faced and overcame many challenges. It is thanks to the contributions of many people that this project came to be, and the few acknowledgments at the beginning of this report do not do justice to their efforts.

References

1. [1] Global Journal of Researches in Engineering Electrical and Electronics Engineering Volume 13 Issue 5 Version 1.0 Year 2013 Type: Double Blind Peer Reviewed International Research Journal Publisher: Global Journals Inc. (USA) Online ISSN: 2249-4596 & Print ISSN: 0975-5861
2. [2] "Bangladesh Gazette: Renewable Energy Policy of Bangladesh 2008", published in November 06, 2008. http://lib.pmo.gov.bd/.pdf.
3. [3] A.Z.A. Saifullah1, Md. Abdul Karim2, Md. Raisul Karim3 1Professor & Chair, Department of Mechanical Engineering, IUBAT – International University of Business Agriculture and Technology, Dhaka 1230, Bangladesh, 2Lecturer, Department of Mechanical Engineering, IUBAT – International University of Business Agriculture and Technology, Dhaka 1230, Bangladesh, 3MSc Student, Dhaka University of Engineering and Technology (DUET), Gazipur 1700, Bangladesh.
4. [4] Planning and Development of Wind Farms: Wind Resource Assessment and Siting
5. [5] Mortensen, Niels Gylling Publication date: 2012Document Version Publisher's PDF, also known as Version of record Link back to DTU Orbit Citation (APA): Mortensen, N. G. (2012). Planning and Development of Wind Farms: Wind Resource Assessment and Siting. Danmarks Tekniske University.
6. [6] John O. Dabiri," potential Order-of-magnitude Enhancement of Wind Farm Power Density via Counter- rotating Vertical-axis Wind Turbine Array," Journal of Renewable and Sustainable Energy, Volume 3, Issue 4, July 19, 2011.
7. [7] Published by Elsevier B.V. Selection and peer-review under responsibility of the International Scientifi c Committee of the "2nd International Through-life Engineering Services Conference" and the Programme Chair – Ashutosh Tiwari
8. [8] Allen,S.R.Hammond, G.P., McManus, M.C.,2008. Prospects for and barriers to domestic micor- generation:A United Kingdom perspective.Appl.Sheldahl R.E., Klimas P.C., and Feltz L.V. Aerodynamic Performance of 5-MeterDiameter Darrieus Turbine with Extruded Aluminum NACA-0015 Blades, Sandia Laboratories, Albuquerque, Report SAND 80-0179, 1980

9. [9] Strickland J.H., The Darrieus Turbine: A Performance Prediction Model Using Multiple Streamtubes, Sandia Laboratories Report SAND 75-0431, 1975
   ECROC (Energy Commission of the Republic of China), White paper of energy policy of the Republic of China. Taipei, Taiwan, 2000.
10. [10] Kato,S., and Widiyanto, A,1999, " A Life Cycle Assessment Scheme for Environmental Load of Power Generation Systems with NETS Evaluation Method," Proc. Of IJPGC 1999

11. [11] 1. M. A. Donelan, W. M. Drennan, K. B. Katsaros, J. Geophys. Res. 27, 2087 (1997).
    a. 2. A. V. Babanin, Geophys. Res. Lett. 33, L20605 (2006).
    b. 3. A. V. Babanin, A. Ganopolski, W. R. C. Phillips, Ocean Model. 29, 189 (2009).
12. [12] Bertagnolio, F., Sørensen, N., Johansen, J.: Profile catalogue for airfoil sections based on3D computations. In: Risø-R-1581(EN) (2006) Davidson, L., Cokljat, D., Fr¨ohlich, J., Leschziner, M.A., Mellen, C., Rodi, W.: LESFOIL:Large Eddy Simulation of Flow Around a High Lift Airfoil. In: Notes on Numerical FluidMechanics, vol. 83. Springer (2003)
13. [13] Gilling, L., Sørensen, N.N., Davidson, L.: Detached Eddy Simulations of an Airfoil inTurbulent Inflow. In: 47th AIAA Aerospace Sciences Meeting Including the New Hori-zons Forum and Aerospace Exposition, Orlando, Florida, January 5-8 (2009)
14. [14] Haase, W., Braza, M., Revell, A.: DESider - A European effort on hybrid RANS-LES mod-elling. In: Notes on Numerical Fluid Mechanics and Multidisciplinary Design, vol. 103.
15. [15] Springer, Berlin (2009) Johansen, J., Sørensen, N.: Application of a Detached-Eddy Simulation model on airfoilflows. In: 14th Symposium IEA Joint Action, Aerodynamics of Wind Turbines, Boulder,CO (December 2000)
16. [16] Li, D.: Numerical simulation of thin airfoil stall by using a modified DES ap-proach. International Journal for Numerical Methods in Fluids 54(3), 325–332 (2007), doi:10.1002/fld.1403.
17. [17] Madsen, J., Lenz, K., Dynampally, P., Sudhakar, P.: Investigation of grid resolution re-quirements for detached eddy simulation of flow around thick airfoil sections. In: EWEC2009, Parc Chanot, Marseille, France, March 16-19 (2009)
18. [18] McGhee, J.R., Walker, B.S., Millard, B.F.: Experimental results for the Eppler 387 Air-foil at low Reynolds numbers in the Langley low-turbulence pressure tunnel. In: NASA
19. [19] Technical Memorandum 4062 (1988) Mockett, C.: A comprhensive study of detached-eddy simulation. Ph.D. thesis, Instituteof Fluid Mechanics and Engineering Acoustics, Technische Universit¨at Berlin (2009)
20. [20] Schneemann, J., Knebel, P., Milan, P., Peinke, J.: Lift measurements in unsteady flow conditions. In: EWEC 2010, Warsaw, Poland, April 20-23 (2010)

21. [21] Somers, D.M., Tangler, J.: Design and experimental results for the S809 Airfoil.NREL/SR-440-6918 UC Category:1213 D 97000206, 1–104 (1997) Spalart, P.R., Allmaras, S.R.: A one-equation turbulence model for aerodynamic flows.
22. [22] Recherche Aerospatiale (1), 5–21 (1994) Spalart, P.R., Jou, W., Strelets, M., Allmaras, S.: Comments on the feasibility of LES forwings, and on a hybrid RANS/LES approach. In: Advances in DNS/LES, vol. 1 (1997)
23. [23] Spalart, P.R.: The uses of DES: natural, extended, and improper. Invited presentation atthe DESider Hybrid RAN-LES Symposium, Stockholm, Sweden, July 14-15 (2005) Spalart, P.R., Deck, S., Shur, M., Squires, K., Strelets, M., Travin, A.: A new versionof detached-eddy simulation, resistant to ambiguos grid densities. In: Theoretical andComputational Fluid Dynamics, vol. 20, pp. 181–195 (2006)
24. [24] Spalart, P.R., Rumsey, C.L.: Effective Inflow Conditions for Turbulence Models in Aero-dynamic Calculations. AIAA Journal 45(10), 2544–2553 (2007)
25. [25] Spalart, P.R.: Detached-eddy simulation. Annual Review of Fluid Mechanics 41,181–202 (2009) Tangler, J., Somers, D.M.: NREL Airfoil Families for HAWTs. In: AWEA, pp. 1–12(1995)