EXPERIMENTAL ANALYSIS OF COMMERCIAL VERTICAL AXIS WIND TURBINE

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Abstract—**The main objective of the project is to harvest and recapture the maximum amount of wind energy. The unused and the considerable amount of the wind is used to drive the vertical wind turbine which in turn will use the kinetic energy of the wind to produce the electrical energy. If the efficiency of the turbine is increased, then more power can be generated thus bringing down the need for expensive power generators. This could reduce pollution as well as the cost of power for the common people. Power can be generated and stored by a wind turbine with little or no pollution..Unlike the traditional horizontal axis wind turbine (HAWT), vertical axis wind turbines effectively capture turbulent winds. Our aim is to design the turbine which will capture the maximum of wind in any direction by placing it at the optimum place and height considering both the cost and the safety of the system. This system can be used in large numbers to generate huge amount of useful electric energy that can be used to fulfil the demand of electricity.**

Keywords—Vertical Axis Wind Turbine, VAWT, Wind Tunnel, Wind Turbine,Vertical Axis, Helical

I. Introduction

The drag-type vertical axis wind turbines (VAWTs) have advantages of simple structure, self-starting at low wind speed and low cost. 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. New concepts of vertical axis wind turbines are introduced such as the helical types particularly for use in urban environments where they would be considered safer due to its lower rotational speeds avoiding the risk of blade ejection and since they can catch the wind from all directions. If the efficiency of a wind turbine is increased, then more power can be generated thus decreasing the need for expensive power generators that cause pollution. This would also reduce the cost of power for the common people. The wind is literally there for the taking and doesn't cost any money. Power can be generated and stored by a wind turbine with little or no pollution. If the efficiency of the common wind turbine is improved and widespread, the common people can cut back on their power costs immensely.

A. Problem Statement

Horizontal axis wind turbines are typically more efficient at converting wind energy into electricity than vertical axis wind turbines. For this reason, they have become dominant in the 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.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.

B. Importance of the Project

This project is to harvest and recapture the maximum amount of wind energy. The unused and considerable amount of wind is used to drive the vertical wind turbine, which will use the kinetic energy of the wind to produce the electrical energy. Increased turbulence levels yield greater fluctuations in wind speed and direction. Unlike traditional horizontal axis wind turbine (HAWT), vertical axis wind turbine effectively captures turbulent winds which are typical in urban settings. An effort is made to create a vertical axis wind mill of 1kW capacity. Our aim is to design the turbine which will capture the maximum of wind in any direction by placing it at optimum place and height by considering both the cost and safety of the system. This system can be used in huge number to generate the huge amount of useful electrical energy. This energy can be stored and transferred to nearest rural places where we can fulfil the demand of electricity. The thought of design directs us to look into the various aspects such as manufacturing, noise, cost which leads us to our additional aim of analysing the system to overcome the usual technical glitches. The project brief involves the design of a small-scale wind turbine that can be easily mass produced and fitted on every household to aid electricity consumption.

C. Project Objectives

The main objective of the project is

i. Be able to generate a non-trivial electricity supply for the household needs when operating. Excess electricity can be fed back into the national grid or charge secondary batteries.

ii. Designed to operate at suitable wind speeds typical to India weather in highways areas.

iii. Possess a fail-safe system as a consequence of an over-speed event.

II. Literature Survey

Rahman, M., Saly-ers, T.E., El-Shahat, A., Ilie, M., Ahmed, M. and Soloiu, V.[1]: Horizontal-axis wind turbines (HAWTs) have been in practice for some time and are heavily favoured over Vertical-axis wind turbines (VAWTs) for large-scale power generation; however, research of VAWTs has gained growing interest in recent years because of the opportunities available for small-scale and off-grid power generation which favours the use of VAWTs.

Morshed, K.N., Rahman, M., Molina, G. and Ahmed, M. (2013) Wind [2] VAWTs have many advantages for small scale wind energy applications. Interest in VAWT technology has recently grown due to potential for off-grid power supply in several different applications. One of the greatest advantages for VAWTs over traditional HAWTs is the ability to self-start in some designs. Under low wind speed conditions, many VAWTs begin to rotate without the added expense of actuators or controls.

Abraham, J.P., Mowry, G.S., Plourde, B.P., Sparrow, E.M. and Minkowycz, W.J. (2011) [3] For VAWTs the generator may be located on the ground rather than high in the air. This provides much more convenient and cost efficient installation and maintenance than that of HAWTs. Another advantageous feature of VAWTs is the fact that they can accept wind from all directions. Regardless of where the wind is coming from, the turbines generally perform equally as well. For this reason, VAWTs are preferred over HAWTs where unsteady and low speed wind conditions exist. There are three important non-dimensional coefficients that characterize turbine performance.

Ghatage, S.V. and Joshi, J.B. (2012) Optimisation of Vertical Axis Wind Turbine: [4]Tip-speed ratio (*TSR*) is the ratio of blade tip speed to the free-stream wind velocity. It is the product of angular velocity and overall radius, divided by the wind velocity.

Kang, C., Yang, X. and Wang, Y.L. (2013) [5] The moment coefficient (*Cm*), also known as the torque coefficient, characterizes the amount of torque generated by the blade geometry. It is the measured torque divided by the theoretical torque value available in the wind.

Bachu, D., Rajat, G. and Misra, R.D. (2013) [6] Power coefficient is the product of tip-speed ratio and moment coefficient. The power coefficient is the efficiency of the turbine useful way for comparing the efficiencies of different wind turbine designs is plotting the power coefficient vs. tip-speed ratio.

Kamoji, M.A., Kedare, S.B. and Prabhu, S.V. (2009) [7]Savonius VAWTs operate in a tip-speed ratio range of 0 to 1.2 and have a maximum efficiency of 20%. Darrius rotors operate in higher wind speeds and achieve a maximum efficiency of 35 percent, while HAWTs enjoy the highest power coefficients of any turbine type.

Jeon, Keum Soo, Jun Ik Jeong, Jae-Kyung Pan, and Ki-Wahn Ryu, (2014) [8] Savonius wind turbines are drag-type VAWTs with negligible lift forces. The traditional Savonius rotor is made up of two opposite-facing semi-circular buckets. Rotation is caused due to a difference in pressure between the advancing and retreating blades.

When wind strikes the blades of the turbine, two components of drag force are generated on each blade surface. Normal drag force (F_n) acts perpendicular to the blade wall and tangential drag force (F_t) acts along the tangential direction of each blade . Drag-based Savonius VAWTs exemplify high starting torque and perform best at low tip-speed ratios. Much research has been conducted regarding two and three blade rotors of this type. Morshed, Rahman, and Ahmed provided analysis of three-bladed Savonius rotors with different overlap ratios. Models with overlap ratio of 0.12 and 0.26 were compared to a model with no overlap.

III. Description of the Problem Statement

A. *Renewable Energy Sources*

Energy is a hot topic in the news today: increased consumption, increased cost, depleted natural resources, our dependence on foreign sources, and the impact on the environment and the danger of global warming. Wind energy has great potential to lessen our dependence on traditional resources like oil, gas and coal and to do it without as much damage to the environment. Alternative energy sources, also called renewable resources, deliver power with minimal impact on the environment. These sources are typically greener/cleaner than traditional methods such as oil or coal. In addition, alternative resources are inexhaustible. While many renewable energy projects are large-scale, renewable technologies are also suited to rural and remote areas and developing countries, where energy is often crucial in human development. Former United Nations Secretary-General Ban Ki-moon has said that renewable energy has the ability to lift the poorest nations to new levels of prosperity. As most of renewable energy technologies provide electricity, renewable energy deployment is often applied in conjunction with further electrification, which has several benefits: electricity can be converted to heat (where necessary generating higher temperatures than fossil fuels), can be converted into mechanical energy with high efficiency, and is clean at the point of consumption. In addition, electrification with renewable energy is more efficient and therefore leads to significant reductions in primary energy requirements, because most renewable energy technologies do not need a thermodynamic cycle with high losses. Renewable energy systems are rapidly becoming more efficient and cheaper and their share of total energy consumption is increasing. The demand for electrical energy is increasing exponentially and relying on fossil fuel resources will pose a threat to the humankind as the availability of these resources are getting limited. Hence the focus should be on the renewable energy sources such as solar, wind, tidal etc. These sources have been coined renewable due to their continuous replenishment and availability for use over and over again. The popularity of renewable energy has experienced a significant upsurge in recent times due to the exhaustion of conventional power generation methods and increasing realization of its adverse effects on the environment. This popularity has been bolstered by cutting edge research and ground breaking technology that has been introduced so far to aid in the effective tapping of these natural resources and it is estimated that renewable sources might contribute about 20% – 50% to energy consumption in the latter part of the 21st century. Over the past few decades, due to extensive use of fossil energy sources, world is facing global warming and increasing greenhouse effect. Higher need of energy and less accessibility to power supplies requires the use of renewable sources of energy like wind-energy, which is most prominent for suitable applications. Renewable energy options have many people around the world talking as they desire to reduce their costs.

Fig 1. Renewable Resources

B. Wind Energy

Wind power is the use of air flow through wind turbines to provide the mechanical power to turn electric generators. Wind power, as an alternative to burning fossil fuels, is plentiful, renewable, widely distributed, clean, produces no greenhouse gas emissions during operation, consumes no water, and uses little land. The net effects on the environment are far less problematic than those of fossil fuel sources.

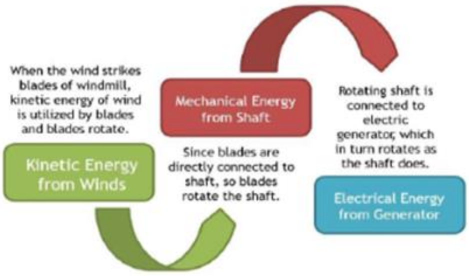

Fig 2 Basic power generation concept

Wind farms consist of many individual wind turbines, which are connected to the electric power transmission network. Onshore wind is an inexpensive source of electric power, competitive with or in many places cheaper than coal or gas plants.

Fig 3 Wind farm

Offshore wind is steadily and stronger than on land and offshore farms have less visual impact, but construction and maintenance costs are considerably higher. Small onshore wind farms can feed some energy into the grid or provide electric power to isolated off-grid locations.

Fig 4 Offshore Wind farm

Wind power gives variable power, which is very consistent from year to year but has significant variation over shorter time scales. It is therefore used in conjunction with other electric power sources to give a reliable supply. As the proportion of wind power in a region increases, a need to upgrade the grid and a lowered ability to supplant conventional production can occur. Power-management techniques such as having excess capacity, geographically distributed turbines, dispatchable sources, sufficient hydroelectric power, exporting and importing power to neighbouring areas, energy storage, or reducing demand when wind production is low, can in many cases overcome these problems. Weather forecasting permits the electric-power network to be readied for the predictable variations in production that occur.

IV WIND TURBINES

A. Types of wind turbines

The major classification of wind turbines is related to the rotating axis position in respect to the wind; care should be taken to avoid confusion with the plane of rotation. Wind turbines are classified mainly of two types:

(i) Vertical axis (VAWT)

(ii) Horizontal axis (HAWT).

B. Horizontal Axis Wind Turbine

HAWT are the most common type of wind turbines built across the world. Horizontal-axis wind turbines (HAWT) have the main rotor shaft and electrical generator at the top of a tower, and must be pointed into the wind. Small turbines are pointed by a simple wind vane, while large turbines generally use a wind sensor coupled with a servo motor. Most have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator. Since a tower produces turbulence behind it, the turbine is usually positioned upwind of its supporting tower. Turbine blades are made stiff to prevent the blades from being pushed into the tower by high winds. Additionally, the blades are placed a considerable distance in front of the tower and are sometimes tilted forward into the wind for a small amount. The rotor, torque and speed characteristics can be controlled and optimized in modern HAWTs by changing pitch angle of rotor blades. It can be done by using mechanical or electronic blade pitch control system. This technique improves the performances of wind turbine while protecting turbine against extreme wind conditions and over speed.

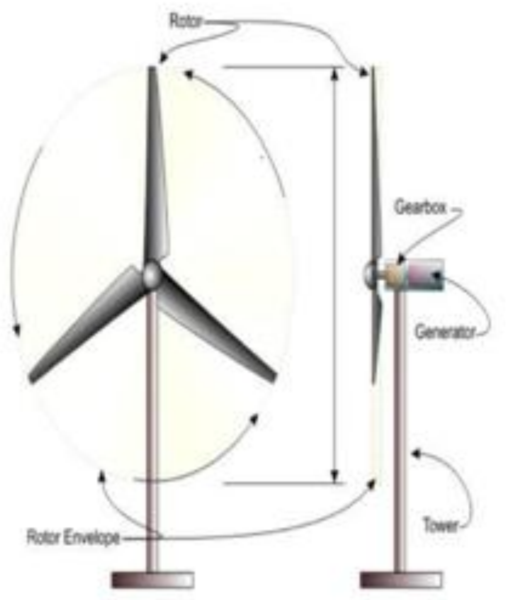

Fig 5 HAWT

C. Vertical Axis Wind Turbine

VAWT is a type of wind turbine which have two or three blades and in which the main rotor shaft runs vertically. They are however used less frequently as they are not as effective as HAWT. The Vertical Axis Wind Turbine (VAWT) is the most popular of the turbines that people are adding to make their home a source of renewable energy. While it is not as commonly used as the Horizontal Axis Wind Turbine, they are great for placement at residential locations and more. Vertical Axis Wind Turbines are designed to be economical and practical, as well as quiet and efficient. They are great for use in residential areas whereas the HAWT is best for use at a business location. Vertical turbines spin on the vertical axis and comes in various shapes sizes and colours. Its movement is similar to a coin spinning on the edge. The main difference between the VAWT and HAWT is the position of blades. In HAWT, blades are on the top, spinning in the air while in VAWT, generator is mounted at the base of the tower and blades are wrapped around the shaft.

The VAWT, as the turbines are oftener shortened, feature the following qualities:

(i) Two to three blades with a vertically operating main rotor shaft – the more blades that you have on the unit, the more wind energy it will receive and the more efficiency it will offer.

(ii) The position of the blades is different in the VAWT. On this model, the base of the tower holds the generator, and the blades then wrap themselves around the shaft. People use the VAWT because they can be placed closer to the ground, which makes them acceptable and effective for use at a residential location.

ü With the vertical axis wind turbine, the rotor shaft is arranged in a vertical pattern

ü The VAWT are easier and more affordable to maintain than horizontal units

ü One complains that some users have with the VAWT is that is creates less wind energy, which may cause a number of different noises to be heart. Turbulent air flow is also a possibility that can shorten the life of the system.

ü Installation of the VAWT onto the roof will cause the wind speed to double for maximum wind turbulence and wind energy usage.

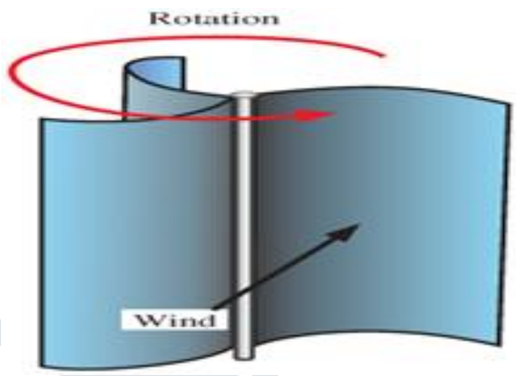

Fig 6 VAWT Rotation of axis

D. Types of Vertical Axis Wind Turbine

There exists two major type of Vertical Axis Wind Turbine and they are namely:

(i) LIFT TYPE

(ii) DRAG TYPE

There are two ways of extracting the energy from the wind depending on the main aerodynamic forces used:

- The drag type takes less energy from the wind but has a higher torque and is used for mechanical applications as pumping water. The most representative model of drag-type VAWTs is the Savonius.
- The lift type uses an aerodynamic aerofoil to create a lift force, they can move quicker than the wind flow. This kind of windmills is used for the generation of electricity. The most representative model of a lift-type VAWT is the Darrieus turbine; its blades have a troposkien shape which is appropriate for standing high centrifugal forces.

ü **Darrieus Wind Turbine**

Darrieus Wind Turbine is commonly known as an “Eggbeater” turbine. It was invented by Georges Darrius in 1931. A Darrius is a high speed, low torque machine suitable for generating alternating current (AC) electricity. Darrius generally require manual push therefore some external power source to start turning as the starting torque is very low. Darrius has two vertically oriented blades revolving around a vertical shaft.

The Darrieus wind turbine offers the following features:

ü These eggbeaters shaped turbines are great at efficiency; however, they are not as reliable.

ü In order to use the Darrieus wind turbine, you must have an outside source of power in order to start them

ü It is in your best interest to choose a wind turbine that has at least three blades.

ü To support such a wind turbine, it is necessary that you have a superstructure which will connect it near the top bearing.

Fig 7 Darrieus Wind Turbine

ü **Savonius Wind Turbine**

A Savonius vertical-axis wind turbine is a slow rotating, high torque machine with two or more scoops and is used in high-reliability low-efficiency power turbines. Most wind turbines use lift generated by aerofoil-shaped blades to drive a rotor, the Savonius uses drag and therefore cannot rotate faster than the approaching wind speed. The Savonius wind turbine is the more popular of the two types. Let's go ahead and look at some of the features these VAWT offer to the homeowner.

1. As a drag type of turbine, these units are less efficient.
2. · When you live in an area that has strong and gusting winds or when you need a unit that self-starts, this is the best type available to you.
3. · This unit is larger than the Darrius model.

Savonius vertical axis wind turbine needs to be manually started. The slow speed of Savonius increases cost and produces less efficiency. Savonius turbines with drag-based rotors are adopted from the two more extensive arrangements of vertical wind turbines because of their advantages. These proposed models incorporate a conventional Savonius with two different edges criteria and 90-degree helical bend models with two sharp edges. Helical plans are better spread the connected torque over a total transformation resulting in positive torque over every single operational point. Moreover, helical models with 2 cutting edges have the best self-starting ability in low wind speeds

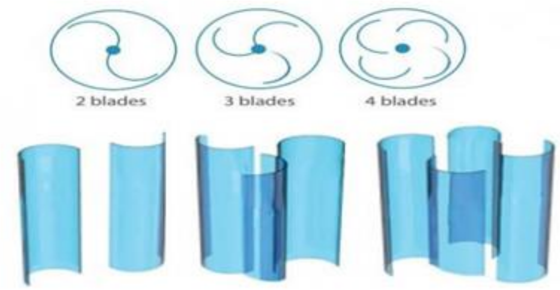

Fig 8 Wind Turbine Blades

E. Aerodynamic Parameters

In this, the rotor design parameters are described as well as the model used to calculate its aerodynamic performance. The model limitations are exposed and the computer algorithm and its validation are presented.

Wind turbine design parameters:

ü Swept area
ü Power and power coefficient
ü Tip speed ratio
ü Blade chord
ü Number of blades
ü Initial angle of attack

ü **Swept area**

The swept area is the section of air that encloses the turbine in its movement, the shape of the swept area depends on the rotor configuration, this way the swept area of an HAWT is circular shaped while for a straight-bladed vertical axis wind turbine the swept area has a rectangular shape and is calculated using:

$$S = 2RL$$

where S is the swept area [m^2], R is the rotor radius [m], and L is the blade length [m].The swept area limits the volume of air passing by the turbine. The rotor converts the energy contained in the wind in rotational movement so as bigger the area, bigger power output in the same wind conditions.

ü **Power and power coefficient**

The power available from wind for a vertical axis wind turbine can be found from the following formula:

$$P_w = 0.5\, \rho\, S\, V_0^{\;3}$$

where Vo is the velocity of the wind [m/s] and ρ is the air density [kg/m3], the reference density used its standard sea level value (1.225 kg/m^3 at 15ºC), for other values the source (Aerospaceweb.org, 2005) can be consulted. Note that available power is dependent on the cube of the airspeed.The power the turbine takes from wind is calculated using the power coefficient:

Cp =Captured mechanical power by blades/ Available power in wind

Cp value represents the part of the total available power that is actually taken from wind, which can be understood as its efficiency.There is a theoretical limit in the efficiency of a wind turbine determined by the deceleration the wind suffers when going across the turbine. For HAWT, the limit is 19/27 (59.3%) and is called Lanchester-Betz limit (Tong, 2010, p. 22). For VAWT, the limit is 16/25 (64%) (Paraschivoiu I., 2002, p. 148).These limits come from the actuator disk momentum theory which assumes steady, inviscid and without swirl flow. Making an analysis of data from market small VAWT, the value of maximum power coefficient has been found to be usually ranging between 0.15 and 0.22.This power coefficient only considers the mechanical energy converted directly from wind energy; it does not consider the mechanical-into-electrical energy conversion, which involves other parameters like the generator efficiency.

ü **Tip Speed Ratio**

The power coefficient is strongly dependent on tip speed ratio, defined as the ratio between the tangential speed at blade tip and the actual wind speed.

TSR =Tangential speed at the blade tip /Actual wind speed

$= Rm / V_o$

where ω is the angular speed [rad/s], R the rotor radius [m] and Vo the ambient wind speed [m/s]. Each rotor design has an optimal tip speed ratio at which the maximum power extraction is achieved.

ü **Blade chord**

The chord is the length between leading edge and trailing edge of the blade profile. The blade thickness and shape are determined by the aerofoil used, in this case it will be a NACA aerofoil, where the blade curvature and maximum thickness are defined as percentage of the chord.

ü **Number of blades**

The number of blades has a direct effect in the smoothness of rotor operation as they can compensate cycled aerodynamic loads. For easiness of building, four and three blades have been contemplated.The calculations used to evaluate the power coefficient of the turbine do not consider the wake turbulence effects of the blade, which affect the performance of adjacent blades.

ü **Initial angle of attack**

The initial angle of attack is the angle the blade has regarding its trajectory, considering negative the angle that locates the blade's leading edge inside the circumference described by the blade path.

E. Noise and vibrations

Wind turbines can create a constant humming noise that is considered an annoyance as well as produce vibrations that over time can ruin the integrity of a roof. This has hindered the popularity of consumers wanting to have wind turbines mounted to their roof. This has limited wind turbines to be mounted on poles next to houses but many city ordinance laws prohibit this in residential areas. As a wind turbine is spinning and producing electricity it creates a constant vibration. This constant vibration can damage the shingles around the base as well as damage the trusses around the area where they are mounted. These vibrations are very difficult to prevent, so it is important to have a mounting system that will disperse the vibrations before reaching the actual structure of the house. Many roofing companies do not put a warranty on the roof if there is a wind turbine due to the result of the vibrations. This will dissuade a consumer away from having a wind turbine mounted on the roof. Another issue that dissuades a consumer from using wind turbines is the constant humming noise produced when a turbine is generating electricity.A VAWT as opposed to a horizontal axis turbine does not produce as much noise as the traditional turbines due to design differences of the turbines as well as the path of motion of the blade. Another reason that VAWT are more for residential areas is their ability to operate at peak efficiency with turbulence that is produced by roof contours. When wind is traveling over roof peaks and different slopes of roofs, they produce a turbulent wind pattern that actually disrupts horizontal axis turbines from producing electricity. This turbulent wind pattern caused by roof peaks does not disrupt the functioning of VAWTs, as well as produce as loud of noise compared to HAWT systems. The rise in popularity of roof mounted VAWTs is opening research into a way to eliminate harmful vibrations from turbines that cause roof damage. This project goes into solving and improving the flaws of roof mounting systems as well as improvements to the overall design of the VAWT blade design in methodical steps that can be seen in the next chapter.

V. DESIGN AND ANALYSIS

A. BLADE DESIGN

The design of blades for the drag type savonius wind turbine is made using the CATIA software. The rotor blades of the savonius wind turbine are designed using the software CATIA which is user friendly. At first the length and diameter of the blades and shaft are determined. Then the angle between the blade ends is determined. The rotor blades are connected with the frame which is mounted along with the rotating shaft. Then the whole setup is assembled on the base plate. The blades are assembled in a manner which is facing opposite to each other. A gap is present in between the blades and the shaft which provides necessary path for air to pass through.

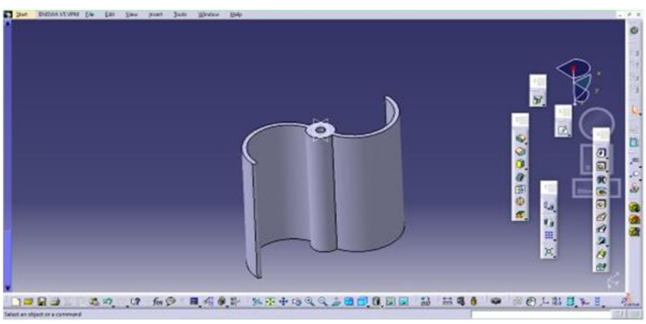

Fig 9 CATIA design of a straight model

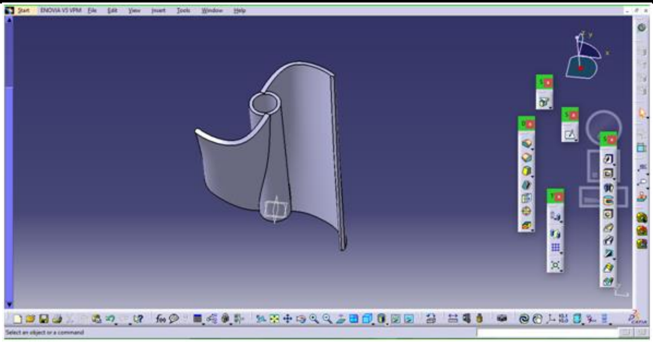

Fig 10 CATIA design of helical twisted model

B. ANALYSIS

Computational fluid Dynamics (CFD), a specialist area of mathematics and a branch of fluid mechanics, is used routinely in a diverse range of safety-critical engineering systems. Computational Fluid Dynamics is the most common method to create a simulation over the constructed experiment model that represents the real-world flow. This reduces the cost and time for the practical setup which has to be done. The aim of this simulation is to predict the pressure and velocity over the sides of the concave and convex blades surfaces. At first the primary goals of the experiment have to be set. Then the flow rate has to be given. The boundary layer has to be created around the testing specimen. The flow is regulated within the boundary layer. The pressure flow indicates the distribution of pressure rate over the surface of the rotating blades. Computational Fluid Dynamic (CFD) simulations are performed with ANSYS Fluent to study aerodynamic characteristics of the models. ANSYS Fluent software is used for computational fluid dynamics simulations. The simulations are performed in three dimensions to gather moment coefficient data over time for one rotation.

In order to understand the pressure distributions and aerodynamic characteristics of the various blades in the study, numerical simulations are performed using commercial CFD software ANSYS Fluent. The CAD models are imported into ANSYS Design Modeler, and fluid regions are added to the geometry. For transient three-dimensional analysis of VAWTs, two separate fluid domains are needed for simulation. A 9-inch diameter spherical enclosure around the model is used for a rotating zone. A second, stationary zone is created with a uniform box enclosure as the far-field domain. The fluid domains are discretized using ANSYS Meshing. Each mesh consists of around 500,000 tetrahedral elements since the maximum allowable number of cells for ANSYS Fluent Academic is 512,000.

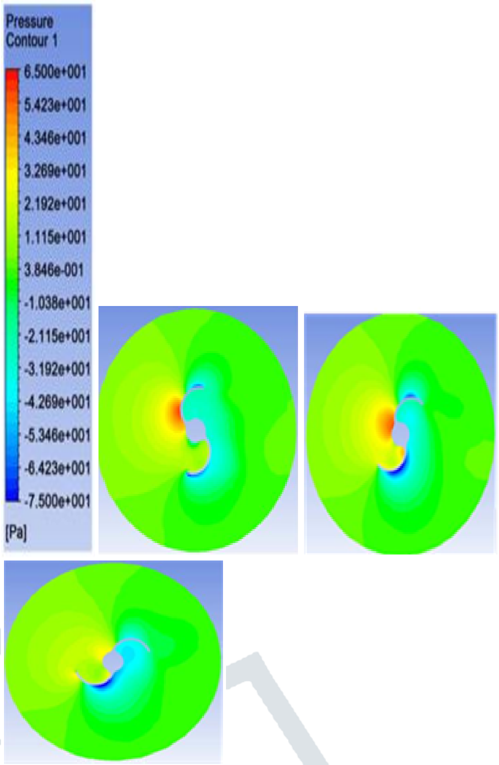

Fig 11 Pressure contours

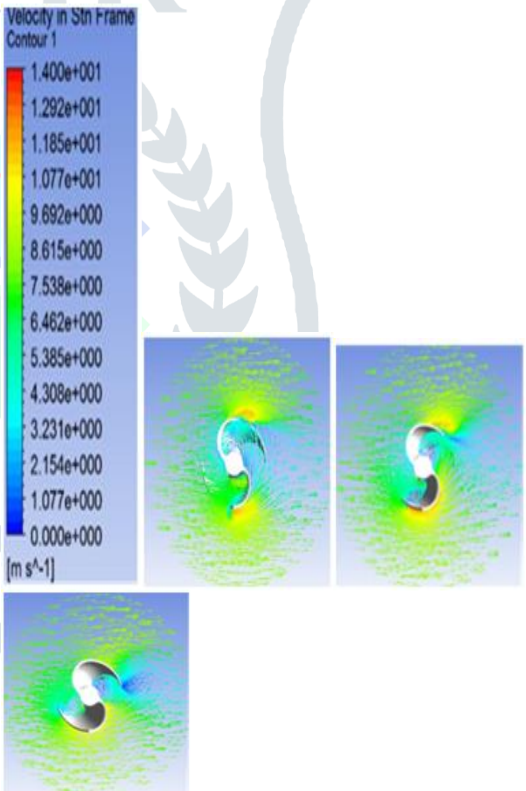

Fig 12 Air velocity vectors of twisted helical

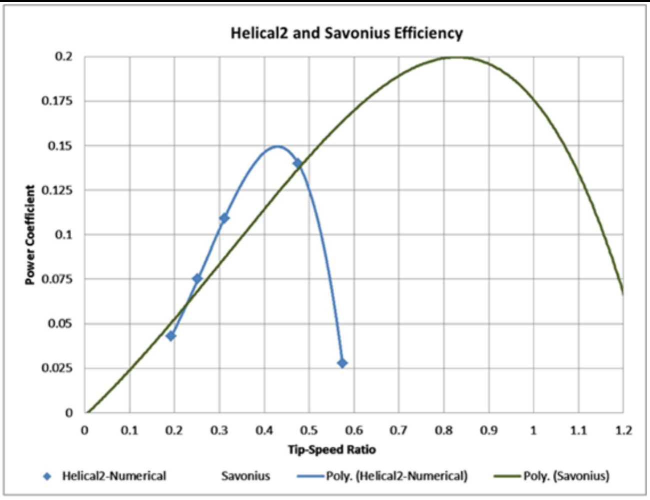

Fig 13 Efficiency

VI. FABRICATION

A. 3D PRINTING

3D printing is any of various processes in which material is joined or solidified under computer control to create a three-dimensional object, with material being added together (such as liquid molecules or powder grains being fused together). 3D printing is used in both rapid prototyping and additive manufacturing. 3D printing has shown itself to be a promising technology for manufacturing commercial vertical axis wind turbine.

B. ADDITIVE MANUFACTURING

Rapid prototyping utilizes three-dimensional (3D) printing to create these custom VAWT, a type of additive manufacturing process. The printing process builds the material layer by layer. Within this protocol, several technologies have developed, which have advantages for different objectives. For instance, when manufacturing VAWT, the sintering-based machines offer the ability to create new or difficult metal alloys. The 3D printing process is also a strong option when creating prototypes as only one may be needed and not a large quantity. However, when manufacturing prototypes, engineers and manufacturers consider all options including additive and subtractive manufacturing, often blending the two processes and other methods in order to create a suitable product

C. PROCESS

Since the design of helical blades is difficult in manufacturing the dies for u and would also cost more, the wind blades were designed in Catia and were built in Fused Deposition Modelling (FDM). FDM is an additive manufacturing process that belongs to the material extrusion family. In FDM, the object is built by selectively depositing melted material in a predetermined path layer-by-layer. The materials used are Polylactide (PLA) polymers that come in a filament form which is a biodegradable polyester. This also provides the model to be lighter.

Fig 14 3D printed blades

VII. CONCLUSION

A. 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 contributive to the production of clean renewable electricity from the wind even under less than ideal sitting conditions. It is hoped that they may be constructed used high-strength, low-weight materials for deployment in more developed nations and settings or with recyclable materials and local skills in less developed countries. The Involute wind turbine designed is ideal to be located at the highways medians to generate electricity, powered by wind. The heavy vehicle traffic gives it an advantage for more wind opportunity. With the idea of putting it on highway medians, it will power up street lights and or commercial use. In most cities, highways are a faster route for everyday commute with different places and in need of constant lighting makes this an efficient way to produce electrical energy.

B. FUTURE SCOPE

An economical, small scale Vertical Axis Wind Involute Turbine is fabricated using 3D printing method. From test results of Vertical Axis Wind Turbine over a wide range of wind speeds, it is noted that this turbine produces 40 watts for a wind speed of 3-3.5 m/s and which can be even increased by following measures.

• Optimizing the design of blades so as to give better aerodynamics.
• Using a best alternator which produces more voltage for low rpm.
• Using gear mechanisms to increase rpm for alternator input and hence can have higher power output.
• Structural fabrication should be more accurate in order to have proper functions of windmill.
• Using fixed base system to reduce the weight of the whole system.

Thus a small scale turbine for energy needs can be satisfied with optimized involute shape Vertical Axis Wind Turbine or combination of Darrieus and Savonius type of Vertical Axis Wind Turbine.

C. ADVANTAGES OF THE PROJECT

ü 3D printing reduces the effort and cost of designing the mould die for the blades.
ü The material used for 3D printing is polylactic acid which is a biomaterial that moves eco-friendly.
ü The vertical wind turbine can easily start up in low winds and also can pick up even in turbulent winds.
ü The design can be easily mounted and can be used for commercial purpose.

ü Maintenance is easy compared to HAWT as the motor is mounted in the base.

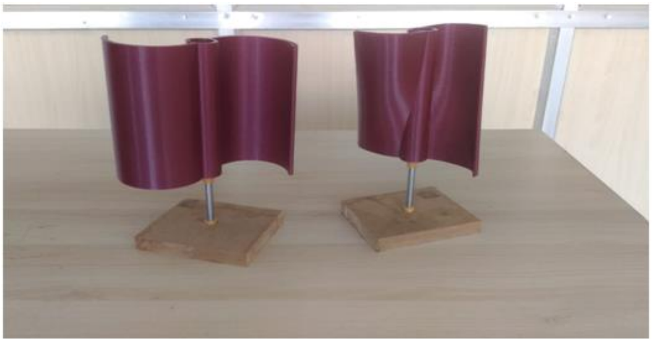

Fig 15 3D printed final product

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