WIND TURBINE

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CERTIFICATE

This is to certify that the Research work titled **SMALL SCALE WIND TURBINE** that is being submitted by **Adil shamshad, Faizan ahmad, Mayank kushwaha and Md Afzal ali** is in partial fulfillment of the requirements for the award of **Bachelor of Technology**, is a record of bonafide work done under my guidance. The contents of this research work, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma.

Supervisor

Internal Examiner **External Examiner**

Approval Sheet

This thesis/dissertation/project report entitled **small scale wind turbine** by **Adil shamshad, Mayank kushawaha, Faizan ahmad and Md Afzal ali** is approved for the degree of bachelor of technology in mechanical engineering.

Examiners

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Declaration

I declare that this written submission represents my ideas in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Acknowledgement

The contributions of many different people, in their different ways, have made this possible. I would like to extend my gratitude to the following.

We are grateful to my supervisor ……..

(Adil shamshad)

(Faizan ahmad)

(Mayank kushwaha)

(Md Afzal ali)

(Department of Mechanical engineering)

ABSTRACT

Due to the increasing environmental and economic cost of fossil fuels, alternative sources of energy are needed. One such source is energy wind energy. Much of the current wind turbine research focuses on large-scale wind turbines. An alternative approach is small-scale wind turbines designed specifically to produce power at low wind speeds. This thesis investigates the design and testing of these turbines. Concerns specific to small-scale design, such as low Reynolds number flow, separation, and low wind speed power generation are addressed. A test apparatus was developed to validate the design procedure, and specific methods to increase power generation under these conditions, such as spanwise and axial roughness, two, three, and four-bladed systems and tip-speed ratios of 1, 3, and 7, were investigated. While many of these methods increased system efficiency, roughness was found to dramatically improve performance, reaching up to 126% increase in power output at a wind speed of 10 mph.

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List of abbreviations

1.	HAWT	Horizontal Axis Wind Turbines
2.	VAWT	Vertical Axis Wind Turbines
3.	BWEA	British Wind Energy Association.
4.	TSR	Tip speed ratio

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Introduction

A turbine converts the kinetic energy of the wind to useful mechanical energy. This energy could be used in mechanical form or turn generator turbines and provide electricity. Just like in the hydropower systems, wind energy is harnessed through conversion of the wind kinetic energy to mechanical energy.

The wind turbines are largely classified into two types- Horizontal Axis Wind Turbines and Vertical Axis Wind Turbines. Large areas installed with wind turbines, that is, wind farms are increasingly emerging today.

Figure 1-wind mill

Wind Characteristics

- **Mean wind speed** − This estimates the annual wind yield though it does not give the distributions.

- **Wind speed distribution** − There are three aspects namely annual, diurnal and seasonal characteristics. Understanding the wind speed variations and the spread is necessary when choosing a site.
- **Turbulance** − This is the chaotic movement of wind in unpredictable patterns. Turbulance results from continuously changing properties of wind motion that impact on energy production and fatigue on blades.
- **Long term fluctuation** − Irregular wind causes unpredictable energy supply. Before a wind turbine is set, the area should be studied for a constant wind flux.
- **Distribution of wind direction** − This is more significant in positioning of the blades especially for horizontal axis types.
- **Wind shear** − Shear is change in wind direction, speed or the height at which the maximum velocity occurs.

There are two broad classifications of wind turbines −

- Horizontal Axis Wind Turbines (HAWT)
- Vertical Axis Wind Turbines (VAWT)

Horizontal Axis Wind Turbines

The propeller-type rotor is mounted on a horizontal axis. The rotor needs to be positioned into the wind direction by means of a tail or active yawing by a yaw motor. HAWTs are sensitive to the changes in wind direction and turbulence which have a negative effect on performance due to the required repositioning of the turbine into the wind flow. The best locations for HAWTs are open areas with smooth air flow and few obstacles. Some HAWTs models are shown in Figure 2.

Figure 2-HAWT

Vertical axis wind turbines (VAWTs)

Vertical axis wind turbines VAWTs are typically developed only for the urban deployment. Changes in wind direction have fewer negative effects on this type of turbine because it does not need to be positioned into the wind direction. However, the overall efficiency of these turbines in producing electricity is lower than HAWTs.

Figure 3-VAWT

1.1 Project background

Small wind turbines have been available for several decades and are in widespread use today, with reportedly over 150,000 machines installed and operating worldwide. Historically, fewer turbines have been sold in the UK than other countries (e.g. the USA), but a recent market survey suggests the UK market is growing . This is likely to be due in part to increasing awareness of climate change and the potential of wind turbines to decrease the carbon emissions associated with electricity generation. Many individuals and organisations are now considering installing small turbines to supply electricity to their houses and commercial building.

In UK government policy, small-scale wind energy is often considered as one of a number of microgeneration technologies. In its 2005 Microgeneration Strategy, the Department of Trade and Industry (DTI, now the Department for Business, Enterprise and Regulatory Reform, BERR) referred to an Energy Saving Trust (EST) study which suggested that by 2050, ‘widespread installation of microgeneration could be reducing household carbon emissions by approximately 15%’C. Various estimates have been made of the carbon saving potential of small-scale wind energy specifically, including one by the British Wind Energy Association (BWEA) which indicated that 2.8 MtCO2 /year is possible. Other sources have suggested figures between 0.7 MtCO2 /year and 9.9 MtCO2 /year, based on different assumptions.

Viewing small-scale wind energy as a microgeneration technology implies that its main use is to directly supply buildings, and following this is the important consideration of where the buildings are located While in general, the suitability of microgeneration technologies depends on building type and energy demand profile, few types of microgeneration are affected significantly by the built environment in which they are installed. Small wind turbines, by virtue of needing to be exposed to high wind speeds, are affected in this way. And while there is considerable experience of successfully installing turbines in open, exposed rural areas, understanding how they will perform in urban locations is technically challenging. This was a key conclusion of an internal scoping study carried out for the Carbon Trust in 2006 by Entec and Paul Arwas Associates. The study also found that, overall:

- There has been limited research into urban small scale wind energy, and both theoretical and empirical evidence of performance is limited; and

- While much can be drawn from existing theory, the best methods for assessing the performance of small turbines in urban areas are unclear

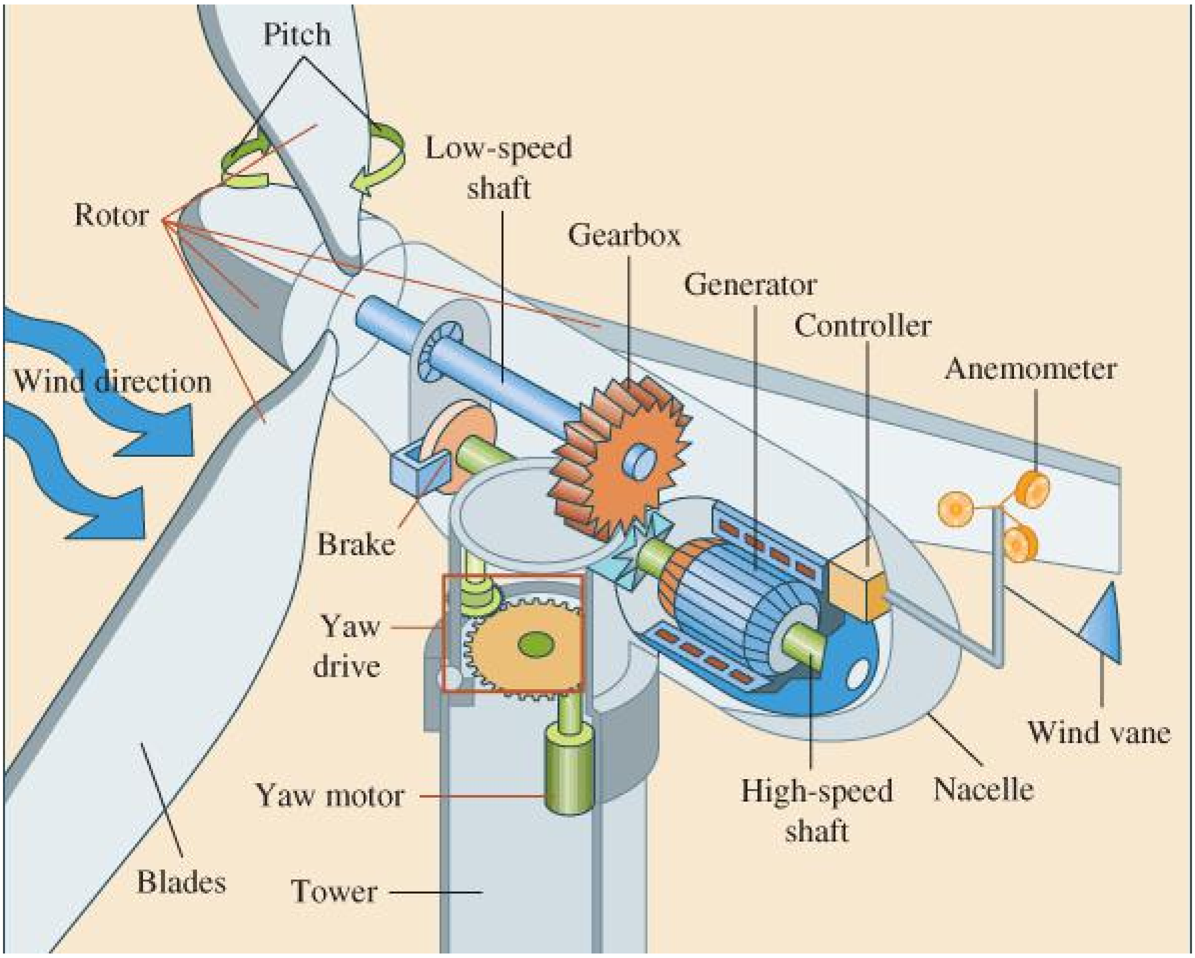


Figure 4-schematic of wind turbine

1.1.1 Function of component

Foundation-Foundation give support to wind turbine. It consist of solid concrete assembly.

Tower-It connect rotor and foundation and raise rotor so that it can operate at required wind.

Rotor and rotor blades- It is rotating part which converts wind energy to rotation.

Nacelle- Contains the key components of the wind turbine including the gearbox , yaw system and electric generator.

Low speed shaft -Connect the rotor hub to the gearbox.

High speed shaft -Drive the electrical generator by rotating at high speed.

Gearbox-The gearbox convert the rotor motion of lower rpm into the higher rpm.

Coupling-Coupling is done between main shaft and the transmission.
Generator-Generates electricity from rotation of shaft.
Controller-It is a self operating system use in control system.it may be a sensor.
Yan mechanism-Turns the nacells with rotor into the wind using motors.
Anemometer and wind vane -Measures the speed and direction of the wind while sending signals to the controller to start or stop the turbine.

1.2 Wind Turbine Blade Design

Most wind turbines designed for the production of electricity have consisted of a two or three bladed propeller rotating around a horizontal axis. It's obvious to say that these propeller like wind turbine blade designs convert the energy of the wind into usable shaft power called torque. This is achieved by extracting the energy from the wind by slowing it down or decelerating the wind as it passes over the blades. The forces which decelerate the wind are equal and opposite to the thrust type lifting forces which rotates the blades.

Just like an aeroplane wing, wind turbine blades work by generating lift due to their curved shape. The side with the most curve generates low air pressure while high pressure air beneath pushes on the other side of the blade shaped aerofoil. The net result is a lifting force perpendicular to the direction of flow of the air over the turbines blade. The trick here is to design the rotor blade in such a way as to create the right amount of rotor blade lift and thrust producing optimum deceleration of the air and therefore better blade efficiency.

If the turbines propeller blades rotate too slowly, it allows too much wind to pass through undisturbed, and thus does not extract as much energy as it potentially could. On the other hand, if the propeller blade rotates too quickly, it appears to the wind as a large flat rotating disc, which creates a large amount of drag.

Then the optimal tip speed ratio, TSR, which is defined as the ratio of the speed of the rotor tip to the wind speed, depends on the rotor blade shape profile, the number of turbine blades, and the wind turbine propeller blade design itself. So which is the best blade shape and design for wind turbine blades.

Generally, wind turbine blades are shaped to generate the maximum power from the wind at the minimum construction cost. But wind turbine blade manufacturers are always looking to develop a more efficient blade design. Constant improvements in the design of wind blades has produced new wind turbine designs which are more compact, quieter and are capable of generating more power from less wind. Its believed that by slightly curving the turbine blade, they're able to capture 5 to 10 percent more wind energy and operate more efficiently in areas that have typically lower wind speeds.

1.2.1 Wind Turbine Blade Design

So which type of blade shape would produce the greatest amount of energy for a wind turbine? – Flat blades are the oldest blade design and have been used for thousands of years on windmills, but this flat broad shape is becoming less common than other types of blade design. The flat blades push against the wind, and the wind pushes against the blades. The resulting rotation is very slow because the blades that are rotating back on the up stroke after generating power are in opposition to the power output. This is because the blades are acting like huge paddles moving in the wrong direction, pushing against the wind giving them the name of drag-based rotor blades.

However, flat blade designs offer significant benefits for the DIY'er compared to other wind blade designs. Flat rotor blades are easy and cheap to cut from a sheets of plywood or metal ensuring that the blades have a consistent shape and size. They are also the easiest to understand requiring less design and construction skills, but there efficiency and the ease of generating electrical power is very low.

Curved blades are very similar to a long aeroplane wing (also known as an aerofoil) which has a curved surface on top. The curved blade has air flowing around it with the air moving over the curved top of the blade faster than it does under the flat side of the blade, which makes a lower pressure area on top, and therefore, as a result, is subjected to aerodynamic lifting forces which create movement.

These lifting forces are always perpendicular to the curved blade's upper surface which causes the blade to move rotating around the central hub. The faster the wind blows, the more lift that is produced on the blade, hence the faster the rotation. The advantages of a curved rotor blade compared to a flat blade is that lift forces allow the blade tips of a wind turbine to move faster than the wind is moving generating more power and higher efficiencies. As a result, lift based wind turbine blades are becoming more common now. Also, home made pvc wind turbine blades can be cut from standard sized drainage pipes having the curved shape already built-in giving them the best blade shape.

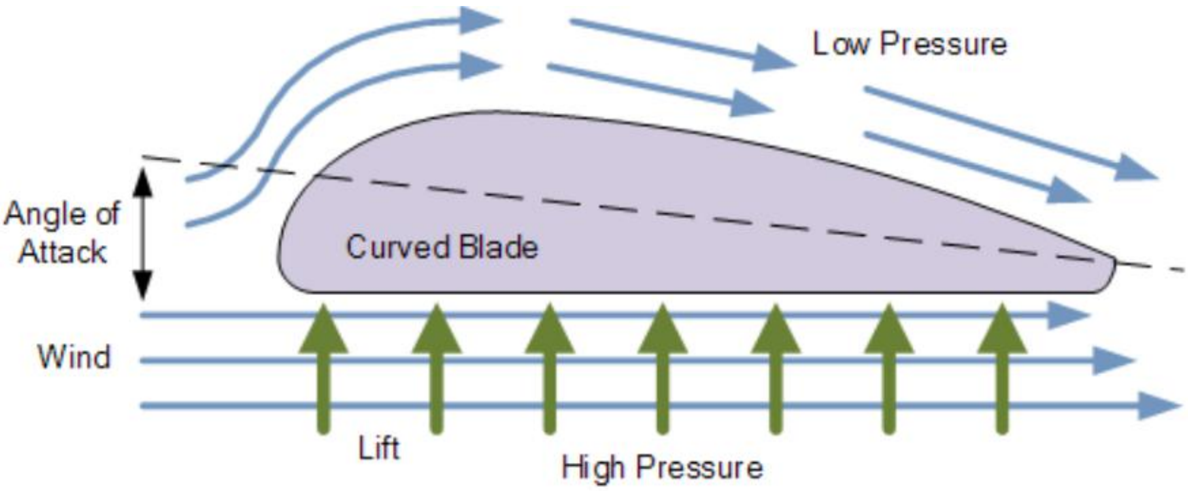


Figure 5-Curved Blade Air Flow

But curved blades also suffer from drag along its length which tries to stop the motion of the blade. Drag is essentially the friction of air against the blade surface. Drag is perpendicular to Lift and is in the same direction as the air flow along the blade surface. But we can reduce this drag-force by bending or twisting the blade and also tapering it along its length producing the most efficient wind turbine blade design.

The angle between the direction of the oncoming wind and the pitch of the blade with respect to the oncoming wind is called the "angle of attack". As this angle of attack becomes larger, more lift is created but as the angle becomes even larger, greater than about 20^o, the blade will begin to decrease lift. So there is an ideal pitch angle of the rotor blade that creates the best rotation and modern wind turbine rotor blades are actually designed with a twist along their length from a steep pitch at their root to a very shallow pitch at their tip.

As the speed at the tip of a rotating blade is faster than it is at its root or center, modern rotor blades are twisted along their length by between 10-to-20^o from root to tip so that the angle of attack decreases from where the air is moving relatively slowly near to their root, to where it is moving much faster at the tip. This blade twist maximises the angle of attack along the length, getting the best lift and rotation.

In conclusion, a wind turbines rotor blade length determines how much wind power can be captured as they rotate around a central hub and the aerodynamic performance of wind turbine blades is very different between a flat blade and a curved blade. Flat blades are cheap and easy to make but have high drag forces making them slow and inefficient.

To increase the wind turbine blade efficiency, the rotor blades need to have an aerodynamic profile to create lift and rotate the turbine but curved aerofoil type blades are more difficult to make but offer better performance and higher rotational speeds making them ideal for electrical energy generation.

1.3 Research purpose

A small scale wind turbine can reduce the electricity bill slightly or up to 100% depending on the quality of wind resource of the site.

Small wind turbines are low cost, low maintenance and dependable alternative energy generators which can be installed in short time in very little space and virtually without any additional infrastructure.

The only large investment is in the acquisition of wind speed data at 20M/ 30M height for the open lands & roof top levels across the cities of India.

Figure 6-wind turbine on roof

1.3.1 Assemble a wind turbine

Do it without a crane

After the tower has been built and the generator is in its place, it is time to install the blades that will generate the power. As well, sometimes wind turbine blades get damaged and need to be fixed or repaired. However, moving and installing a crane for managing the blades can be expensive and will take time and resources.

We have designed a lifting method that uses the structure of the wind turbine as a support point. We have designed a solution that only with cables and tighten to the base of the generator on the ground will lift (or descend in the case of reparations) the turbine blade in a few minutes. That allows the company to repair or replace a blade in just a fraction of the time it would need with the other methods.

Do it with our blade counterweight tool
When a blade has been assembled it is time to turn the generator and get reay to assemble the next blade**.** However, turning the generator in this situation is not an easy task, because you have a lot of weight on one side that makes it difficult to rotate the axis**.** You need something powerful enough to do the job. We have designed a blade counterweight tool that will produce the rotation force needed to turn the generator and orientate it to the position we need to assemble the blades.

1.3.2 Wind Turbine Modeling and Simulation

Wind turbines are unique devices that are typically anchored to the ground but operate in the atmosphere, which subjects them to a variety of torques and loads as weather conditions change. Modeling this behavior for land-based wind turbines is difficult enough, but the issues become even more complex for floating offshore wind turbines that may respond to such conditions by moving and can be subjected to rolling seas that may affect their performance.

FAST

FAST is an aeroelastic computer-aided engineering tool for horizontal-axis wind turbines. FAST is NREL's primary computer-aided engineering tool for simulating the coupled dynamic response of wind turbines. It enables the analysis of a range of wind turbine configurations, including:

- Two- or three-bladed horizontal-axis rotor
- Pitch or stall regulation
- Rigid or teetering hub
- Upwind or downwind rotor
- Lattice or tubular tower
- Land-based or offshore
- If offshore, fixed-bottom or floating substructures.

Simulator for Wind Farm Applications

The Simulator for Wind Farm Applications (SOWFA) employs computational fluid dynamics to allow users to investigate wind turbine and wind power plant performance under a full range of atmospheric conditions and terrain. The tool allows researchers and wind power plant designers to examine and minimize the impact of turbine wakes on overall plant performance.

Wind-Plant Integrated System Design and Engineering Model

The Wind-Plant Integrated System Design & Engineering Model (WISDEM) is a set of models for assessing the overall cost of energy of a wind power plant. The models use the wind turbine and plant cost and estimated energy production, as well as financial models, to estimate cost of energy and other wind power plant system attributes. WISDEM models include:

- Rotor Aero
- Rotor Structure
- Nacelle Structure
- Tower Structure
- Turbine Costs
- Plant Balance of System Costs
- Plant Operating Expenses
- Plant Energy Production
- Plant Finance.

1.4 Materials

Wind energy is captured by the rotation of the wind turbine's rotor blades. Rotor blades have historically been made of wood, but because of its sensitivity to moisture and processing costs modern materials such as glass fiber reinforced plastic (GFRP), carbon fiber reinforced plastic (CFRP), steel and aluminum are replacing the traditional wooden units.

Wood is a composite of cellulose and lignin. Wood finds many engineering applications and has long been a common construction material. Woods are potentially interesting because of their low density, but their rather low stiffness makes it difficult to limit the (elastic) deflections for very large rotor blades. Even wood materials with cellulosic fibers all aligned in the major loadbearing directions are close to the maximum performance possible for wood. Furthermore, wood is a natural material and thus environmentally attractive, but at the same time difficult to obtain in reproducible and high quality, which is a requirement for stable and economical manufacturing of rotor blades and thus economically attractive wind energy.

Steel is an alloy of iron and carbon. Older style wind turbines were designed with heavier steel blades or nickel alloy steels which have higher inertia, and rotated at speeds governed by the AC frequency of the power lines. The high inertia buffered the changes in rotation speed and thus made power output more stable. The purpose of nickel alloy is lessens distortion in quenching and lowers the critical temperatures of steel and widens the range of successful heat treatment. Nickel alloy possesses good corrosion and oxidation resistance. Alloy steel was once thought to be an optimum choice for blade fabrication, but was soon abandoned because of its high weight and low fatigue level.

Aluminium is a silvery white metal with a density about a third that of steel. Aluminum was only implemented in testing situations because it was found to have a lower fatigue level than steel. Aluminium is ductile and good heat conductor. Aluminium is a low price metal but it has good reliability and has a low tensile strength. Aluminum is lightweight, but weaker and less stiff than steel.

The fibers and the matrix materials like polyesters, vinyl esters, epoxies etc., are combined into the composites. These composites have good properties like mechanical, thermal and chemical properties. Firstly, the glass fibers are amorphous with isotropic properties. Most glass reinforced products are made with E-glass (electrical glass), which has good electrical and mechanical properties and high heat resistance. E-glass is available as chopped fiber, milled fiber, continuous roving, woven roving, woven fabric, and reinforcing mat. Glass fibers for composites have good properties like moderate stiffness, high strength, and moderate density. Carbon fibers are composed of nearly pure carbon, which forms a crystallographic lattice with a hexagonal shape called graphite. In recent years carbon fibers have become of increasing interest because of the requirements presented by the ever-larger rotor blades and the decreasing price of carbon fibers. Carbon fibers for composites have an excellent combination of very high stiffness, high strength, light weight and low density.

Aramid fibers (aromatic polyamides) are characterized by excellent environmental and thermal stability, static and dynamic fatigue resistance, and impact resistance. These fibers have the highest specific tensile strength (strength/density ratio) of any commercially available continuous-filament yarn. Aramid reinforced thermoplastic composites have excellent wear resistance. Aramid fibers have low or very low densities.

1.4.1 Why material knowledge is critical

From an engineering perspective, the early structural failures and continuing risks had their genesis in an early lack of understanding of the wind forces acting on these large structures. This included not only the effects of the steady-state component of the incident wind flow field, but more particularly the turbulence component. Research, field measurements, and improved modeling, augmented by operational experience, have greatly increased our understanding of these stochastic forcing functions and the response of the wind turbine. Nevertheless, it is still true that the turbulence structure of the wind contributes the most uncertainty in the design and sizing of the major structural components of a wind turbine.

From the perspective of a designer, this uncertainty continues to be due in part to incomplete knowledge of the turbulence and its description and in part to the difficulty of modeling the structural vibrational responses. However, a major contributor is uncertainty about the long-term responses of the wind turbine materials to the turbulent stochastic loadings. The specific longterm responses of interest here are fatigue failures-that is, failures due to the cumulative effects of many millions of flexural cycles of a structural component. Fatigue failures represent the greatest uncertainty with regard to the long-term service lifetime (typically projected to be 20 to 30 years) of the major structural components of a wind turbine. Thus, fatigue failures represent a major uncertainty in the life-cycle CoE.

Uncertainty about the properties of materials causes the wind turbine designer either to add more weight (and cost) than is required or to misjudge and inadequately size a component so that failure occurs (usually more costly). To further improve the economics of wind turbine systems and increase their range of use, improved materials properties are required. This is particularly true with regard to the long-term fatigue properties of composite materials. As used thus far in wind turbines, composite materials are combinations of glass, other synthetic fibers, or wood in a resin matrix. With the anticipated increasing use of these and other composite materials, improved knowledge about both their static strength and their fatigue properties becomes critical in order to assure both short-term performance and the long-term life required of these power systems. This knowledge base is particularly critical for composites because of the wide variation in their geometries, constituents, and manufacture In addition to the need for improved materials knowledge, there is also a need for increased awareness in the wind turbine community (within both the federal and the private sectors) of advanced manufacturing processes.

1.4.2 Selection of Materials

A material is that out of which anything is or may be made. Much number of factors are affecting for the material selection. They are properties of materials, performance requirements, material's reliability, safety, Physical attributes environmental conditions, availability, disposability and , recyclability, and finally economic factors. In these properties,

1) One of the most important factors affecting selection of materials for engineering design is the properties of the materials. The important properties of the materials are mechanical, thermal, chemical properties..,etc.
2) The material of which a part is composed must be capable of performing a part's function with out failure.
3) A material in a given application must also be reliable.
4) A material must safely perform its function.
5) Physical attributes such as configuration, size, weight, and appearance sometimes also serve functional requirements can be used.
6) The environment in which a product operates strongly influences service performance.
7) A material must be readily available, and available in large enough quantity, for the intended application.
8) The cost of the materials and the cost of processing the materials into the product or part. The development and manufacture of satisfactory products at minimum cost is to make a sound, economic choice of materials.

1.5 Project objectives

Fossil fuels have been used extensively all over the world to satisfy energy demands. However, their availability is limited and their negative impact on the environment undeniable. Due to this, the need to develop alternative energy resources was recognized a few decades ago. Among different alternatives that have been developed, wind energy appears as a promising option to be implemented in many parts of the world. In order to make wind energy more competitive and attractive to investors, new energy systems are desired. Specifically, it is desired to have a higher energy output.

Shrouded wind turbine is still new technology and has many challenges including high capital costs and low performance issues. The technical challenges are mainly to overcome

1-The high frequency of changes of wind direction .
2-The unpredictable and low wind velocity.
3-The high turbulence flow which are very site specific.

Diffuser augmented wind turbine (DAWT) can offer solution to the first two challenges. Placing a diffuser around a horizontal axis wind turbine has been shown to increase the power output compared to a bare turbine. it generates low-pressure region behind it, which assists the turbine to capture more wind energy.

2

Literature review

2.1 Introduction

Now-a-days, renewable energy sources are gaining more attention in power sectors because of the efforts to reduce the usage of fossil fuels to generate the electrical power .And wind power in modern era has become the most established sources in generating the electricity amongst all the renewable sources because of its promising technical and economic prospects. Wind power generation has continued to increase globally. With the latest wind annual report it is stated that in 2015 around 392 GW is installed all over the world which can sufficiently supply 4% of world's electricity demand .And it will continues to grow approximately 24% per year globally. With the worldwide rise of generation of electricity through wind turbines, the impact on the electric utility grids has also increased. By the end of 2015, six countries including China (145362 MW), Spain (23,025 MW), Germany (44,947 MW), USA (74,471 MW), India (25,088 MW) and UK (13,603 MW) had over 10,000 MW of the installed capacity.

In Asia, India is the second leading wind market, offering abundant prospects for international as well as domestic players. India is now amongst the top five countries for wind power installed capacity worldwide. The total renewable energy installation connected with the electric grid in India attained almost 33,792 MW. In the starting of 2015, Wind power is about11% of total installed capacity of 260.8 GW and about 66.5% of total renewable energy capacity.

2.2 Review

[1] Shin'ya Obara et.al. If electric power is supplied using an independent micro-grid connected to renewable energy, it can flexibly match the energy demand characteristics of a local area. And an independent micro-grid is expected to be effective in cutting greenhouse gas discharge and energy costs ,as well as in eliminating the need for an emergency power supply system. Since the output of renewable energy is unstable, other energy equipment needs to cover the stability of output. Thus, the operating conditions of an independent micro-grid that supplies power with natural power sources and fuel cells are investigated. The operation conditions of a fuel-cell independent micro-grid with wind power generation were investigated by numerical analysis. Step loads and an apartment house power load model were analyzed using the dynamic characteristics of a fuel cell obtained from experiments. The output of wind power generation and fuel cells is controlled by proportional-integral control of an independent micro-grid for rapid power demand change.

[2] ASTILLO et.al. The thesis focuses on the design of a small vertical axis wind turbine rotor with solid wood as a construction material. The aerodynamic analysis is performed implementing a momentum based model on a mathematical computer pro_x0002_gram. A three bladed wind turbine is proposed as candidate for further prototype test_x0002_ing after evaluating the effect of several parameters in turbine efficiency, torque and acceleration.The results obtained indicate that wood is a suitable material for rotor construc tion and a further development of the computer algorithm is needed in order to improve the flow conditions simulation. Wind power energy is getting more shares in the total energy production every year, with wind turbines growing bigger and bigger at the rhythm of technology does. While we cannot expect nowadays a totally renewal energy supply in Europe, (some estimations say that it is possible for 2030) there are places where ener_x0002_gy grid has not even arrived and has not any plans for short or midterm time.

[3] J.R. Bumby et.al. The design and development of an axial-flux permanent-magnet air-cored generator foruse as a direct drive generator with small-scale wind and water turbines is described. The generator is designed for simplicity and ease of manufacture and consists of two rotor discs each with permanent magnets located around its periphery. The stator is made of plastic and has a number of bobbin-wound armature coils located around its periphery. A three-phase prototype generator has been designed and built with 16 magnets per rotor disc, 12 armature coils (four per phase) and an overall diameter of 495 mm. The generator produces 1000W at 300 rpm or 2000W at 500 rpm with an electrical efficiency substantially greater than 90%. The generator performs as predicted by the design process.

[4] Ali Naci Celik. Estimation of energy output for small-scale wind power generators is the subject of this article. Monthly wind energy production is estimated using the Weibull-representative wind data for a total of 96 months, from 5 different locations in the world. The Weibull parameter sare determined based on the wind distribution statistics calculated from the measured data, using the gamma function. The wind data in relative frequency format is obtained from these calculated Weibull parameters. The wind speed data in time-series format and the Weibull_x0002_representative wind speed data are used to calculate the wind energy output of a specific wind turbine. The monthly energy outputs calculated from the time-series and the Weibull_x0002_representative data are compared. It is shown that the Weibull-representative data estimate the wind energy output very accurately. The overall error in estimation of monthly energy out puts for the total 96 months is 2.79%. Large-scale wind turbines have already proved themselves as cost competitive electricity generators in locations where wind resource is good enough.

[5] D.M. Whaley et.al. This paper investigates the suitability and experimental testing of a simple power converter for a permanent magnet generator for use with a small-scale variable_x0002_speed wind turbine. The controller uses a switched-mode rectifier in conjunction with a high inductance generator that allows generator torque and power to be controlled via the switch duty-cycle. The controller maximises output power for wind speeds below rated, and limits turbine speed for higher wind speeds. Dynamometer and limited wind turbine test results are presented.

[6] Jorge L et.al. This paper addresses some general issues relatedto the difficulties and uncertainties during the assessment and characterization of micro and small-scale wind-based generation in urban areas. This paper proposes four generic wind turbine models, which could be used for the analysis and selection of optimal wind turbines in target applications, as they accurately represent the range of wind turbines currently available on the market. The analysis in this paper compares results for the expected annual energy outputs and cost-benefit analysis obtained using steady state and dynamic wind turbine models of actual and generic micro/small wind turbines, applying both low-resolution and high-resolution measurements of available.The presented results demonstrate the significance of the accurate assessment of wind resources in urban areas, as well as the importance of the correct modeling of wind turbine characteristics. It is shown that substantial errors, typically overestimating wind turbine performance, are obtained if standard assumptions and current recommendations are used for the analysis of wind turbine performance.

[7] Haining Wang et.al. An ac/dc/ac power converter is an important device used to extract power from variable speed permanent magnet wind generators and feed it into the grid. This paper describes how these converters incorporate maximum power point tracking based on its power feed to the grid at different wind speeds. Using the perma_x0002_nent magnet generator voltage, grid current, and grid voltage sam_x0002_ples, the proposed system achieves an enhanced dynamic behavior. This feature effectively prevents the grid from "boost" charging the dc side of the H-bridge inverter at the start of operation. Since small wind turbines normally do not have expensive pitch control mechanisms, a thyristor-based "dump-load circuit" is employed to protect the turbine from high wind speed operation when dis_x0002_connected from the grid. The thyristor controller also protects the inverter from high dc voltage input from the wind generator at high wind speed. Preliminary results are included using a labora_x0002_tory 2-kW prototype converter.

[8] **G.D. Moor et,al.** Maximum power point tracking methods are presented whereby the loading on the wind turbine is controlled to ensure that the maximum available energy from the wind is captured. The wind turbine system is modelled and used in simulations to evaluate two proposed maximum power point trackers, named anemometer control and calculation control for the purpose of this paper. An additional analog system is also created whereby the complete wind turbine.system can be simulated. An inverter is used to replicate the generator and the loading is controlled using an active rectifier. The results from the simulations and analog system are presented whereby the two trackers are shown to be close

to ideal. The appeal of the calculation method is in the redundancy of an anemometer making it attractive to less expensive, small-scale systems.

[9] Abhishiktha Tummala et.al. Meeting future world energy needs while addressing climatic changes has led to greater strain on conventional power sources. One of the viable sustainable energy sources is wind. But the installation large scale wind farms has a potential impact on the climatic conditions, hence a decentralized small scale wind turbines is a sustainable option. This paper presents review of on different types of small scale wind turbines .i.e., horizontal axis and vertical axis wind turbines. The performance, blade design, control and manufacturing of horizontal axis wind turbines were reviewed. Vertical axis wind turbines were categorized based on experimental and numerical studies. Also, the positioning of wind turbines andaero-acoustic aspects were presented. Additionally, lessons learnt from various studies/countries on actual installation of small wind turbines were presented. As large scale wind turbines alter the global climatic conditions and have adverse effects on the atmosphere, small scale wind tur_x0002_bines offer a great scope for producing valuable power which can be sufficient for domestic needs without altering the climatic conditions.

[10]. Rajarshi Sen. Small wind turbines are low cost, low maintenance and dependable alternative energy generators which can be installed in short time in very little space and virtually without any additional infrastructure. The only large investment is in the acquisition of wind speed data at 20M/ 30M height for the open lands & roof top levels across the cities of India.

3

Problem description

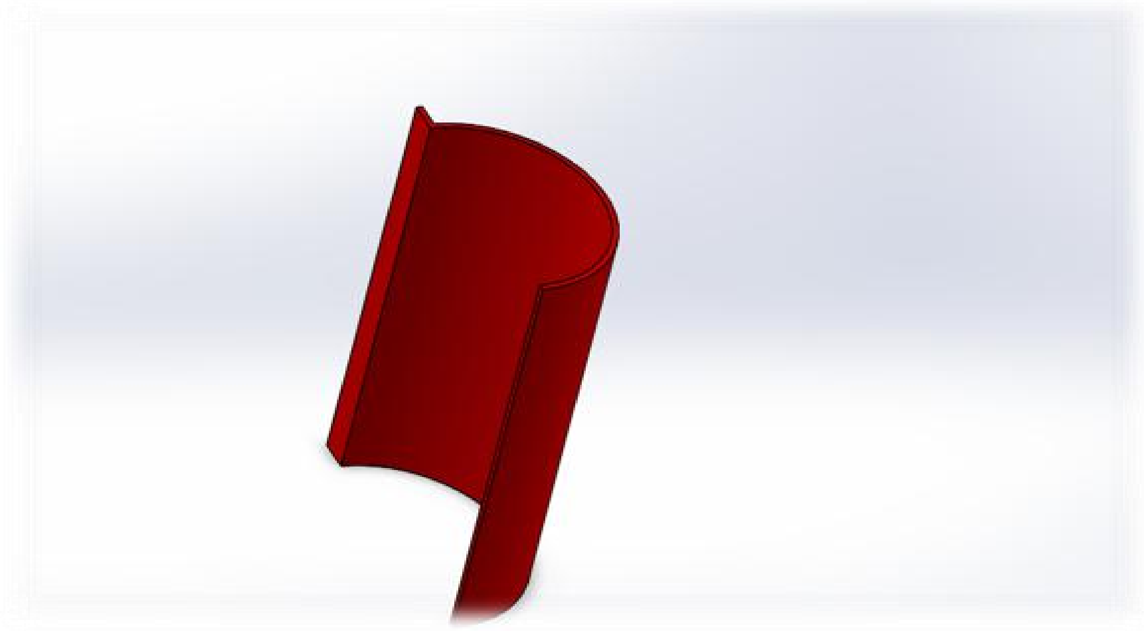
Wind power is a fast growing form of alternative energy and has a potential to make an impact on our campus and community. Our project's goal is to mount two building augmented wind turbines (BAWT) on the science center at University and begin producing wind energy. This will create a clean and environmentally friendly source of energy for our school. We have been measuring wind speeds above the science center for the last year and we plan to mount the turbines this summer. Also, we will be measuring the efficiency of the micro-wind turbines and the influence that structures have on wind flow and velocity.

Currently, we have three wind anemometers collecting wind speed data above the science center at different heights. Once we mount the turbines, the anemometers will be moved next to the turbines. Then, the efficiency of the turbines can be calculated since the actual wind speed will be known. We hope to prove the feasibility of micro-wind power on our campus so that more people will invest in micro-wind energy. The data that we collect will be used to find the most effective and economical way to harness wind energy. This data will also be used by energy engineers as a reference for sizing other micro-wind turbine projects.

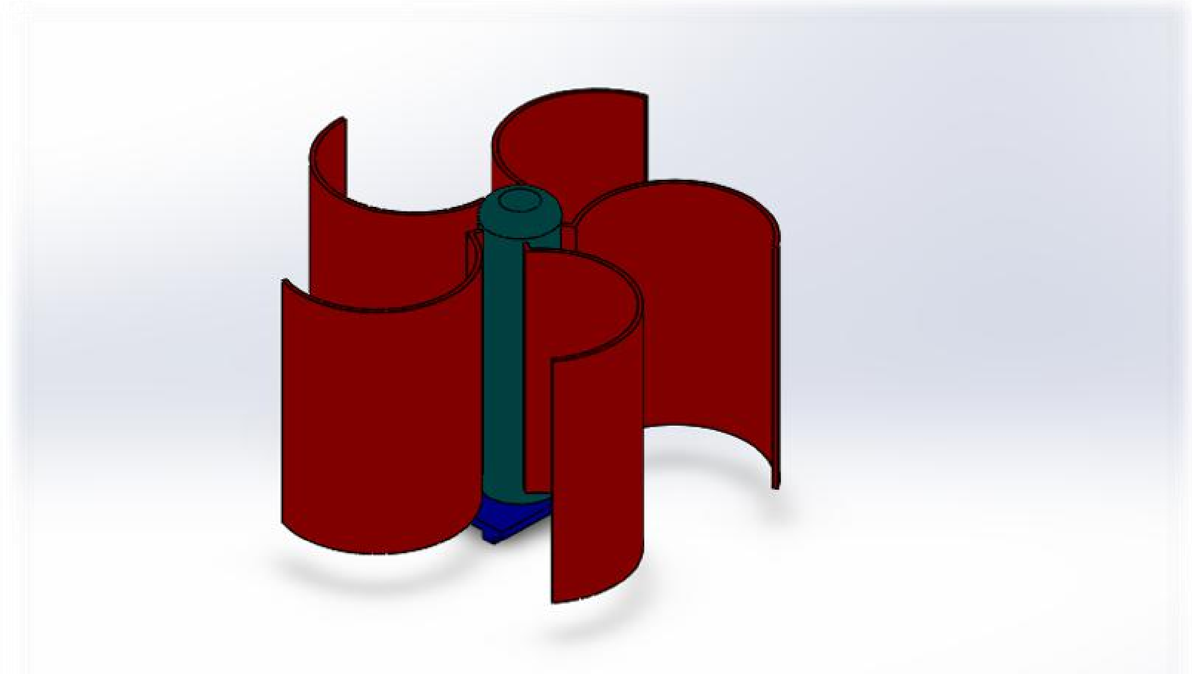
Wind energy has the potential to reduce reliance on fossil fuels. The system is expected to produce 6,000-8,000 kilowatt-hours annually. This is the approximate equivalent to burning 1,000 kilograms of coal. An average United States household uses around 10,000 kilowatt-hours annually making the BAWT system size comparable to what would be necessary for a single family home

4

4.1 Design of single blade for savonious wind turbine



4.2 Design of final savonius turbine



5
5.1 Power contained in wind

$= 1/2m\dot{v}\ 2$

$= 1/2pA\ v\ 3$

where

$\dot{m}$ = mass flow rate

p = density of air

v = velocity of air

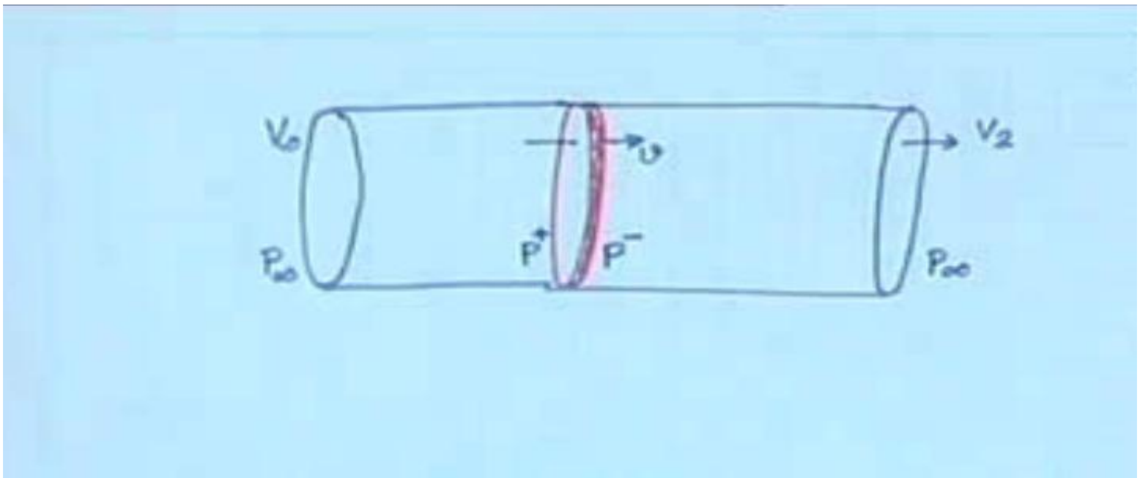
power is directly praposanal to the v 3.

hence power is strongly dependent on the wind speed.

5.2 Maximum quantity that can be extracted

Apply barnauli equation

this state that in a steady flow the sum of all forms of energy in the fluid along the steam line is the same at all the point on the steam line .



- $1/2p\, v_\infty^2 + P_\infty = 1/2p\, v^2 + P_+$
- $1/2p\, v_2^2 + P_\infty = 1/2p\, v^2 + P_-$
- by solving above equation
- $P_+ \quad P_- = 1/2p(v_\infty^2 \quad v_2^2)$
- thrust = $(P_+ \quad P_-)A$
- $= 1/2p(v_\infty^2 \quad v_2^2)$ _1
- thrust = $m(v_\infty \quad v_2)$
- $= pAv\, (v_\infty \quad v_2)$ _2
- by solving these two equation
- $v = 1/2(v_\infty + v_2)$

5.2.1 Maximum amount of energy that can be extracted

- $v = v_\infty (1 \quad a)$ 3
- where; a = axial interface factor
- if; a = 0,no interface
- a = 1,completely blocket
- $v_\infty (1 \quad a) = 1/2(v_\infty + v_2)$
- $v_2 = v_\infty (1 \quad 2a)$
- power extracted
- power = $1/2pAv(v_\infty^2 \quad v_2^2)$
- $= 1/2pA\, v_\infty (1 \quad a) \{v_\infty^2 \quad v_\infty^2 (1 \quad 2a)^2\}$
- Power = $1/2pA\, v_\infty^3 \{4a \quad 8a^2 + 4a^3\}$
- diffrenciate the above equation w.r.t. a
- $1/2pA\, v_\infty^3 \{12a^2 \quad 16a + 4\} = 0$
- $3a^2 \quad 4a + 1 = 0$
- a = 1, 0.333
- for maximum power we get a = .333
- after putting the value of a in above equation

- power = $1/2pA\ v\infty\ 3\ (\ .59259\ )$

5.3 Characterization of Savonius Wind Turbines

- Every Savonius wind turbine is characterized by the swept area $\boldsymbol{As}$. This area influences the energy output of the turbine, and the larger it is, the more energy the turbine collects. $\boldsymbol{As} = \boldsymbol{H} * \boldsymbol{D}$ where H is the height of the turbine and D is its diameter .
- The tip speed ratio of the rotor is defined by the equation: $\boldsymbol{\lambda} = \boldsymbol{Vrotor}\ \boldsymbol{V} = \boldsymbol{\omega * \mathrm{d}}\ \boldsymbol{V}$ where V is the wind speed, ω is the angular velocity of the turbine, and d is the diameter of the semicylindrical blade
- The torque coefficient Ct is the ratio between the torque in the rotor and the theoretical torque that the wind can cause: $\boldsymbol{Ct} = \boldsymbol{T}\ \boldsymbol{Tw} = \boldsymbol{T}\ \mathbf{1}\ \mathbf{4}\ \boldsymbol{\rho * As * d * V2}$ where T is the torque in the rotor and ρ is the air density
- The static torque coefficient Cts expresses the turbines ability to self-start.
- It is the ratio of the maximum static torque in the turbine and the theoretical wind torque.
- $\boldsymbol{Cts} = \boldsymbol{Ts}\ \boldsymbol{Tw} = \boldsymbol{Ts}\ \mathbf{1}\ \mathbf{4}\ \boldsymbol{\rho * As * d * V2}$ where Ts is the maximum static torque .
- The torque in the rotor can be calculated using the following equation: $T = I * \alpha$, where I is the rotor's moment of inertia and α is the rotor's angular acceleration .
- The power coefficient Cp is the ratio of the extracted power from the wind to the available power in the wind: $\boldsymbol{Cp} = \boldsymbol{P\omega}\ \boldsymbol{Pa} = \boldsymbol{T * \omega}\ \mathbf{1}\ \mathbf{2}\ \boldsymbol{\rho * H * D * V3}$

5.4 Two blades Vs. Three Blades

- Savonius wind turbines do perform well at low wind speeds (cut in speed at around 2.5 m/s).
- According to the same study, two blades perform better than three blades as more drag is wasted in the three blades versions.

- The power coefficient of the two blade design is higher than that of the three blade design.
- In their experimental study, It is found that 2 blades do perform better than 3 blades.
- It also found that 4 blades perform even better than 2 blades at low tip speed ratio (TSR), and that 3 blades perform better at higher TSR

5.5 MATERIAL FOR WIND TURBINE

FIBERS

- Fibrous materials are characterized by the fact that they significantly longer than they are wide.
- The exceptional strength and stiffness of fibers make them excellent candidates for turbine blade materials, where the long fibers provide longitudinal stiffness when aligned parallel along the blade length.

CARBON FIBERS

- Carbon fibers have superior mechanical properties with high stiffness, high strength, and low density, albeit along with higher costs.

GLASS FIBERS

- Glass fibers are available at a lower cost compared to their carbon counterparts, and are thus more prevalent in industry.
- They are composed of mainly Sio2 and Al2O3,with other oxides present in small quantities.

ARAMID FIBERS

- Aramid fibers are synthetic fibers that are highly-resistance, making them suited for wind turbines that operate in temperature extremes. The fibers are composed of aromatic polyamide chains held together by strong hydrogen bond that contribute to the toughness of the fiber.

POLYMER MATRIX

- The polymer matrix provides structural support by binding the fibers together and consist of two main classes: thermosets and thermoplastics.

THERMOSETS

- Thermosets contain polymers strongly cross-linked together in irreversible chemical bonds.

THEMOPLASTICS

- Thermoplastics contain polymers that lack these strong chemical bonds so that interactions are reversible.

  They soften when reheated, allowing for the possibility of remolding and repairs when necessary. However the, this property also causes them to melt under high temperatures, making them impractical for some of the harsh conditions wind turbine must endure

REFERENCES

1. **Shin'ya Obara***(2006),Department of Mechanical Engineering, Ichinoseki National College of Technology, Takanashi, Hagisho, Ichinoseki 021-8511, Japan,doi:10.1016/j.ijhydene.2006.07.032
2. **Javier Castillo,**(2011),Degree program in Aeronautical Engineering Tampereen ammattikorkeakoulu, Tampere University of Applied Sciences.
3. **J.R. Bumby and R. Martin,Electr,(2005)** Power Appl., Vol. 152, No. 5,
4. **Ali Naci Celik***,(2002),Mechanical Engineering Department, School of Engineering and Architecture, Mustafa Kemal University, Antakya, 31024 Hatay, Turkey.
5. **D.M. Whaley, W.L. Soong and N. Ertugrul**,(2005), School of Electrical and Electronic Engineering University of Adelaide Adelaide, Australia.
6. **Jorge L. Acosta,**(2011), Student Member, IEEE, Kevin Combe, Saˇsa ˇZ. Djoki´ c, Senior Member, IEEE, and Ignacio Hernando-Gil, Student Member, IEEE.
7. **Haining Wang, Chem Nayar,**(2011), Senior Member, IEEE, Jianhui Su, and Ming Ding.
8. **G.D. Moor,H.J. Beukes,**(2004),University of Stellenbosch, Dept. Electrical Engineering Stellenbosch 7600, South Africa.
9. **K.Suresh Babu et.al**,(2006),1. SRKR Engineering College, Bhimavaram -534 204,AU College of Engineering, Visakhapatnam-530 003(AP)., INDIA.
10. **Abhishiktha Tummala et.al**,(2016),Department of Mechanical Engineering, Amrita School of Engineering, Ettimadai Campus, Amrita Vishwa Vidyapeetham, Coimbatore, 641112, India
11. **Rajarshi Sen**,(2012),Luminous Renewable Energy Pune, India.

PUBLICATIONS

Wind Turbine

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