DESIGN MODIFICATION OF SMALL WIND TURBINE

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ABSTRACT

Electrical energy demand has been continuously increasing. Depleting fossil fuel reserves, environmental concerns, and insufficiency of conventional generation techniques in meeting growing demand, renewable energy use has been widely adopted in the world. When considering the application of renewable energy sources in the world, it can be seen that wind energy is mostly preferred over other renewable energy sources. In this study, a new prototype wind energy conversion system suitable for urban use is designed and manufactured. The proposed design is modular and has flexible structure. In the new design, an outer gear ring attached to turbine blades is used. In the design stage, both the number of blades and the number of outer gear rings are varied to analyze their effect on turbine performance. Performance analysis of the prototype wind turbine is completed under real life conditions and results are given. As a result of this study, it is shown that increasing the gearwheels and blade numbers caused turbine output power increases. The most efficient structure identified during the field analysis is a three gearwheel with six blade system.

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1 INTRODUCTION

Wind turbines harness the wind to produce electrical power. A turbine consists of generator that is equipped with fan blades and placed at the top of a tall tower. The tower must be tall enough to harness the wind at a greater velocity while avoiding obstacles such as trees, hills, and buildings. As the turbine rotates in the wind, the generator produces electrical power. A single wind turbine can range in size from a few kW for residential applications to more than 5 MW.

TYPES OF WIND TURBINE

- Horizontal Axis Wind Turbine
- Vertical Axis Wind Turbine

Fig No 01 Wind Turbine.

As part of the cortication procedure, all wind turbine blade prototypes are subjected to an experimental test procedure in order to ensure that the produced wind turbine blade fulfill the actual design requirements. In addition to experimental tests of load carrying capacity under extreme loading, and tests of the fatigue resistance, it is common practice to supplement with tests of the basic dynamic properties of the blades, such as natural frequencies and damping properties, as these are essential for the dynamic behavior and structural integrity of the entire wind turbine. Usually, these dynamic characteristics are determined for the lowest 3-4 flexural bending modes and for the first torsional mode.

1.1 BLADE PROFILE

However, detailed knowledge to natural frequencies and structural damping characteristics does not by itself guarantee/ensure an optimal dynamic behavior of the wind turbine when subjected to aerodynamic forces arising from the imposed wind field. In recent years, stability problems in wind turbine structures have obtained increasing attention due to the trend towards larger and more flexible structures. A well-known example of a stability problem, which eventually might lead to failure of the whole structure, is the occurrence of dynamic unstable edge- wise vibrations. For aerodynamic loading in general1, and for dynamic stability problems in particular, the deflection patterns of the wind turbine blades are of vital importance. For a wind turbine blade, the deflections of interest are lateral translations (flapwise, edgewise) and cord rotation (about the blades longitudinal axis).

For reasons of simplicity it is common practice to model wind turbine components as beam structures in aero elastic computations. Warping is usually neglected, justified by the fact that the main components are structures with closed cross sections, whereas the structural couplings between flexural bending in the two principal directions and structural couplings between torsion and flexural bending are usually included, as such structural couplings may significantly affect the aerodynamic load characteristics of a wind turbine blade. Although, in principle included in the traditional Euler or Timoshenko beam modeling of wind turbine blades, the correct specification of such structural couplings is a delicate.

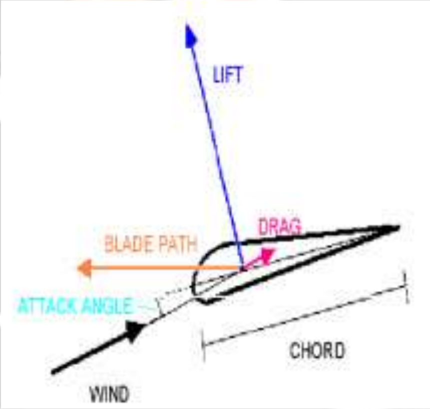


Fig No 02 Blade Profile

1.2 BLADE ELEMENT

For the verification of structural models, it is therefore of interest to extend the traditional dynamic test procedures with new experimental methods suitable for determination of structurally coupled mode shapes. The present report describes a test procedure that, in addition to determination of natural frequencies and structural damping characteristics also provide such information. Modal analysis is by far the most common method used to characterize the dynamics of mechanical systems, and it produces very illustrative and easy interpretable results. The selected experimental procedure is based on the impact modal testing technique.

The specific experimental procedure is designed as to (simultaneously) resolve flap wise translation, edgewise translation and cord rotation in a selected number of cross sections. These deformations are determined with respect to a predefined reference axis based on three measured translational accelerations in each cross section. The positions and directions of action of the three accelerometers are chosen appropriately.

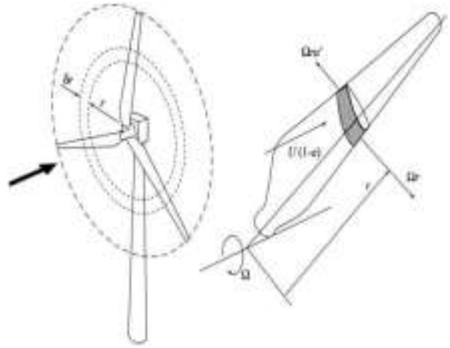
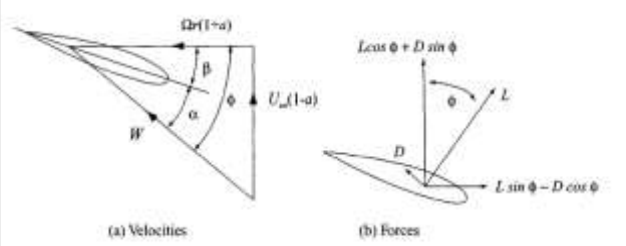


Fig No 03 Schematic representation of blade elements.

An interest for internal blade structural mechanics, as well as for experimental modal analysis, has existed since the early prototypes of large wind turbines. The aerodynamic loading (and damping) is intimately associated with the angle of attack of the incoming flow on the turbine blade – a fact that makes the structural coupling between blade flexture and torsion a matter of utmost importance. The 38 m, filament-wound glass/epoxy blade, designed for the research prototype WTS-3 (Maglarp, Sweden), was subjected to an extensive dynamic test program before delivery. The blade was designed and manufactured by Hamilton Standard, and the tests were conducted in 1981. A ”full” experimental modal analysis was performed using a hydraulic shaker (white noise, two directions at one blade station) and several accelerometers, measuring one edgewise and two flap wise accelerations, at each of about 20 blade stations. The evaluated frequency response functions were then subsequently compared with the corresponding results from a 3D shell element FE-model. The dynamic characteristics corresponding to the seven lowest natural frequencies were analyzed.



(a) Velocities (b) Forces

Fig No04 Blade Element Velocities and Forces

Modal analysis has also been used to identify approximate mode shapes, associated with the dominating deflection direction only (i.e. mode shapes excluding structural coupling between torsion, flapwise and edgewise deformations), of medium size wind turbine blades (LM17 m and LM19 m) . The approximate modes, related to the three lowest natural frequencies, were successfully identified based on the transfer function between a sinusoidal forcing applied in the blade tip and an accelerometer response recorded successively in up to 68 blade stations. Compared to the previous work, the present experimental investigation aims at comparing different experimental modal analysis techniques and subsequently to identify the most appropriate of these considering expenses, time consumption, uncertainty and resolution.

1.3 PERFORMANCE AND COST

The most ideal places for wind turbines are areas that have consistent strong winds. Wind turbines are located in areas with strong winds. It is best for these areas to have an annual capacity factors (which is the actually power output of the turbine divided by the theoretical output) ranging from 20% to over 40%. The life expectancy of a wind turbine is around 20 years. During this time, maintenance may be required on the turbine. Figure 1 shows wind speed vs. power output for some popular turbines. The cost of wind energy is determined by the initial cost of the wind turbine installation, the interest rate on the money invested, and the amount of energy produced. Large-scale wind farms can be installed for about $1,000/kW, while small-scale wind turbine units cost up to $3,000/kW.

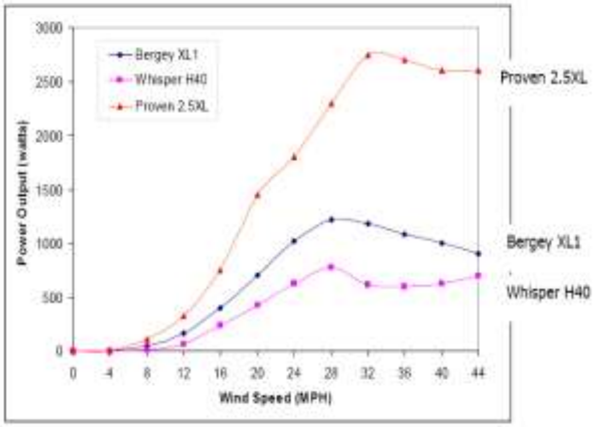


Chart No 01 Power Output vs Wind Speed

1.4 STRENGTHS & WEAKNESSES

Power generated from wind farms can be inexpensive when compared to other traditional power production methods. Typical costs of wind power are between \$0.03/kWh and \$0.06/kWh [2]. Wind turbines do not produce any harmful emissions or require any fuel product for operation. Minimal space is required for a turbine farm and the land below each turbine can be used for animal grazing or farming. A disadvantage of wind turbines is what some people would call an aesthetic problem created when placing them in areas of high population density. Aesthetic and neighborhood codes could discourage or even prohibit the use of wind turbines to supply energy to individual homes.

1.5TWIST, CHORD AND THICKNESS DISTRIBUTION

The twist of a wind turbine blade is defined in terms of the chord line. It is a synonym for the pitch angle. However the twist defines the pitch settings at each station along the blade according to the local flow conditions. The pitch angle (β) is large near the root (where local speeds are low), and small at the tip (where local speeds are high). The apparent wind angle changes along the blade due to the increase in blade speed with increasing distance outboard. Hence to maintain optimum angle of attack of the blade section to the wind, it must be twisted along its length.

1.6 AIM AND OBJECTIVES:

To investigate the structural analysis of the wind blade to increase the performance of the wind energy. This is typically modeled and analyzed by the PRO-E(CATIA) and Ansys software. The different materials like aluminum, steel and composites are used. The analyze stress distribution were performed. Also to optimize the wind blade the different notches are created and this will undergo for analysis.

2. LITERATURE REVIEW

"Optimal Design of Horizontal-Axis Wind Turbines Using Blade-Element Theory and Evolutionary Computation" Andrea Toffolo Ernesto Benini. This paper describes a multi-objective optimization method for the design of stall regulated horizontal-axis wind turbines. Two modules are used for this purpose: an aerodynamic model implementing the blade-element theory and a multi-objective evolutionary algorithm. The former provides a sufficiently accurate solution of the flow field around the rotor disc; the latter handles the decision variables of the optimization problem, i.e., the main geometrical parameters of the rotor configuration, and promotes function optimization. The scope of the method is to achieve the best trade-off performance between two objectives: annual energy production per square meter of Wind Park (to be maximized) and cost of energy (to be minimized).

Examples of the best solutions found by the method are described and their performance compared with those of commercial wind turbines.

"Model Validation and Structural Analysis of a Small Wind Turbine Blade" Pabut, O.; Allikas, Structural design and performance analysis of wind turbine blade is an important part of the design theory and application of wind turbines. Manufacturing costs of a small horizontal axis wind turbine (SHAWT) blade can reach about 20% of the turbine productions costs. Therefore, possible profits resulting from a better structural model and use of suitable composite materials refer to a need of multi-criteria optimization and refined modeling techniques. These statements are furthermore reinforced by the fact that for a cost effective wind turbine solution, the blades must achieve a very long operating life of 20-30 years.

"Blade Performance Analysis and Design Improvement Of A Small Wind Turbine For Rural Areas" Cabanillas Sánchez. Renewable energy technologies have demonstrated to be suitable for providing electricity to rural communities. In the region of Cajamarca, Peru, a wind electrification project has been implemented to provide electricity to the rural community of El Alumbre. To develop the wind turbine IT-PE-100 was designed. The turbine was built for the specific environmental conditions of the mountainous region of the Andes.

This thesis focused on the performance identification of the current blades of the IT-PE-100. It also presents determinate modifications to the blade design improving the Gross Annual Energy Production of the turbine in the environmental conditions of Cajamarca. To conduct this study the software PROPID has been used to perform the analysis regarding the different modifications. The optimum combination of the modifications yielded approximately 20% more energy annually produced with high performance in high wind ranges. This study demonstrated that small changes in the blade design of IT-PE-100 allow a better exploitation of the wind resource. Also, it encourages further research in experimental studies as wind tunnel experiments to validate the optimization model.

"Design and Analysis of Horizontal Axis Wind Turbine Rotor" Arvind Singh Rathore, Siraj Ahmed carried works for an optimization model for rotor design of 750 kW horizontal axis wind turbine. The wind turbine blade is a very important part of the rotor. In this work a blade of length 21.0 m is taken and airfoil for the blade is S809. The airfoil taken is same from root to tip. The model refers to a design method based on Type Approval Provision Scheme TAPS-2000. All the loads caused by wind and inertia on the blades are transferred to the hub. The stress and deflection were calculated on blades and hub by Finite element analysis method. Result obtainedfrom ANSYS is compared with the existing design.

"Design and Optimization of a Small Wind Turbine" John McCosker. Carry out to design a small wind turbine that is optimized for the constraints that come with residential use. The design process includes the selection of the wind turbine type and the determination of the blade airfoil, pitch angle distribution along the radius, and chord length distribution along the radius. The pitch angle and chord length distributions are optimized based on conservation of angular momentum and theory of aerodynamic forces on an airfoil. Blade Element Momentum (BEM) theory is first derived then used to conduct a parametric study that will determine if the optimized values of blade pitch and chord length create the most efficient blade geometry. Finally, two different airfoils are analyzed to determine which one creates the most efficient wind turbine blade. The project includes a discussion of the most important parameters in wind turbine blade design to maximize efficiency.

"Wind Turbine Blade Analysis using the Blade Element Momentum Method" Grant Ingram, This document describes a calculation method for wind turbine blades, this method can be used for either analysis of existing machines or the design of new ones. More sophisticated treatments are available but this method has the advantage of being simple and easy to understand. This design method uses blade element momentum (or BEM) theory to complete the design and can be carried out using a spreadsheet and lift and drag curves for the chosen aero foil. The comments on the document would be gratefully received. Further details on Wind Turbine Design can be provides comprehensive coverage of all aspects of wind energy. Also provide a comprehensive but much briefer overview of Wind Energy.

"Optimal Design of Horizontal-Axis Wind Turbines Using Blade-Element Theory and Evolutionary Computation"AndreaToffolo Ernesto Benini. This paper describes a multi-objective optimization method forthe design of stall regulated horizontal-axis wind turbines. Two modules are used for this purpose: an aerodynamic model implementing the blade-element theory and a multi-objective evolutionary algorithm. The former provides a sufficiently accurate solution of the flow field around the rotor disc; the latter handles the decision variables of the optimization problem, i.e., the main geometrical parameters of the rotor configuration, and promotes function optimization. The scope of the method is to achieve the best trade-off performance between two objectives: annual energy production per square meter of Wind Park (to be maximized) and cost of energy (to be minimized). Examples of the best solutions found by the method are described and their performance compared with those of commercial wind turbines.

"Design and Finite Element Analysis of Horizontal Axis Wind Turbine blade" Nitin Tenguria Mittal.N.D,Siraj Ahmed carried out works for HAWT wind turbine blade, this design is based on Glauert's optimal rotor theory. They were focused on the two segments of blade, root segment and transition segment. Result obtained from ANSYS is compared with the previously done experimental work. In this work they have carried out flap wise loading analysis.

"Structural Optimization Design of Horizontal-Axis Wind Turbine Blades Using a Particle Swarm Optimization Algorithm and Finite Element Method" XinCai , Jie Zhu , Pan and Rongrong Guworkedon optimization method for structural design of Horizontal axis wind turbine blade based on the particle swarm optimization algorithm (PSO) combined with the finite element method (FEM). The main goal is to create an optimization tool and to demonstrate the potential improvements that could be brought to the structural design of HAWT blades. A multi-criteria constrained optimization design model pursued with respect to minimum mass of the blade is developed.

"Blade Design and Performance Analysis of Wind Turbine" Department of Mechanical Engineering, National Institute of Technology, Srinagar, J&K, India. Lab experiments and CFD simulations has proven that for this particular S809 series airfoil, the most effective angle of attack is at 14°. From 6° to 14° the CL will be above a value of 1, and from 3° to 14° the ratio L/D will be over 1, in other words; within this range there will be effective use of the airfoil. The good correlations between wind tunnel data and CFD simulations encourage that future modification on airfoil designs shall be investigated in simulation software. Though, it is emphasized that wind tunnel experiments must still be done to validate the accuracy of the evolving designs and computer models.

The CFD software used in this report has limitations in terms of flexibility in meshing. Acquiring different software with more mesh options, or just aspecific meshing software, is therefore recommended. Ideally there should have been carried out simulations on both high and low Reynolds Numbers. It is difficult to acquire the necessary data for this, and due to time constraints only one Re is being investigated here. It is recommended that future work on the same subject acquire experimental data for more than one velocity. Future work should also consider using Spalart-All marasandk-ω instead of k-ε, which may have a better result on flow close to boundary layers**.**

3. OVERVIEW OF MATERIAL PROPERTIES

3.1 INTRODUCTION TO COMPOSITES

Mankind has been aware composite materials since several hundred years before Christ and applied innovation to improve the quality of life. Although it is not clear has to how Man understood the fact that mud bricks made sturdier houses if lined with straw, he used them to make buildings that lasted. Ancient Pharaohs made their slaves use bricks with to straw to enhance the structural integrity of their buildings, some of which testify to wisdom of the dead civilization even today. Contemporary composites results from research and innovation from past few decades have progressed from glass fiber for automobile bodies to particulate composites for aerospace and a range other applications.

Composites that forms heterogeneous structures which meet the requirements of specific design and function, imbued with desired properties which limit the scope for classification. However, this lapse is made up for, by the fact new types of composites are being innovated all the time, each with their own specific purpose like the filled, flake, particulate and laminar composites**.**

Fibers or particles embedded in matrix of another material would be the best example of modern-day composite materials, which are mostly structural. Laminates are composite material where different layers of materials give them the specific character of a composite material having a specific function to perform. Fabrics have no matrix to fall back on, but in them, fibers of different compositions combine to give them a specific character. Reinforcing materials generally withstand maximum load and serve the desirable properties.

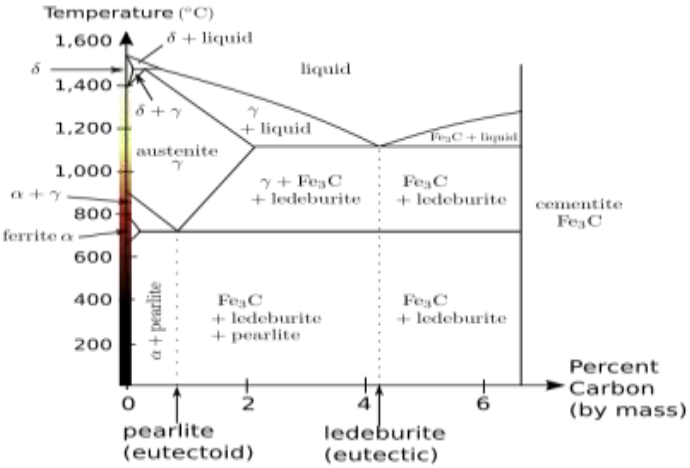
3.2 DETAILS OF STEEL

Steel is an alloy of iron and carbon that is widely used in construction and other applications because of its high tensile strength and low cost. Carbon, other elements, and inclusions within iron act as hardening agents that prevent the movement of dislocations that naturally exist in the iron atom crystal lattices.

The carbon in typical steel alloys may contribute up to 2.1% of its weight. Varying the amount of alloying elements, their formation in the steel either as solute elements, or as precipitated phases, retards the movement of those dislocations that make iron so ductile and weak, or thus controls qualities such as the hardness, ductility, and tensile strength of the resulting steel. Steel's strength compared to pure iron is only possible at the expense of ductility, of which iron has an excess.

Although steel had been produced in bloomer furnaces for thousands of years, steel's use expanded extensively after more efficient production methods were devised in the 17th century for blister steel and then crucible steel. With the invention of the Bessemer processing the mid-19th century, a new era of mass-produced steel began. This was followed by Siemens-Martin process and then Gilchrist-Thomas process that refined the quality of steel. With their introductions, mild steel replaced wrought iron.

Further refinements in the process, such as basic oxygen steelmaking (BOS), largely replaced earlier methods by further lowering the cost of production and increasing the quality of the metal. Today, steel is one of the most common materials in the world, with more than 1.3 billion tons produced annually. It is a major component in buildings, infrastructure, tools, ships, automobiles, machines, appliances, and weapons. Modern steel is generally identified by various grades defined by assorted standards organizations.



FigNo3.1 Material properties

3.3 DETAILS OF E-GLASS EPOXY

Glass fiber (also spelled glass fiber) is a material consisting of numerous extremely fine fibers of glass. Glassmakers throughout history have experimented with glass fibers, but mass manufacture of glass fiber was only made possible with the invention of finer machine tooling. In 1893, Edward Drummond Libbey exhibited a dress at the Exposition incorporating glass fibers with the diameter and texture of silk fibers. This was first worn by the popular stage actress of the time Georgia Cayvan. Glass fibers can also occur naturally, as Pele's hair.

Glass fibre has roughly comparable mechanical properties to other fibers such as polymers and carbon fiber. Although not as strong or as rigid as carbon fiber, it is much cheaper and significantly less brittle when used in composites. Glass fibers are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), also popularly known as "fiberglass". This structural material product contains little air, is more dense than glass wool, and is not an especially good thermal insulator.

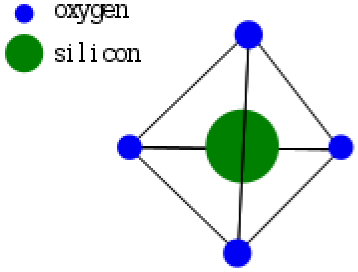


Fig No 3.2 Molecular Structure of Glass

Although pure silica is a perfectly viable glass and glass fiber, it must be worked with at very high temperatures, which is a drawback unless its specific chemical properties are needed. It is usual to introduce impurities into the glass in the form of other materials to lower its working temperature. These materials also impart various other properties to the glass that may be beneficial in different applications. The first type of glass used for fiber was soda lime glass or A-glass ("A" for the alkali it contains). It is not very resistant to alkali. A new type, E-glass, was formed; this is an alumino-borosilicate glass that is alkali-free (<2%). This was the first glass formulation used for continuous filament formation.

3.4 THERMALPROPERTIES

Glass fibers are useful thermal insulators because of their high ratio of surface area to weight. However, the increased surface area makes them much more susceptible to chemical attack. By trapping air within them, blocks of glass fiber make good thermal insulation, with a thermal conductivity of the order of 0.05 W/ (m.K).

SPECIFICATION

Main technical parameter as follows:
1. Machine Type: horizontal-axis wind turbine

- **Blade form: propeller**
- **Blade number: 3 pieces**
- **Blade material: Glass Fibre Reinforced Plastic**
- **Type of generator: permanent-magnet 3 phase AC**
- **Type of tower: guy wire or free standing**
- **Power: 3KW**
- **Blade diameter (m): 5.0**
- **Rated rotor speed (r/min):200**
- **Rated speed (m/s): 10**
- **Rated power: 3KW**
- **Max power: 4.5KW**
- **Output voltage (v): 220**
- **Startup wind speed (m/s): 3**
- **Work speed (m/s): 3-30**
- **Security wind speed (m/s): 50**
- **High of tower (m): 8**
- **Top quality except tower: 235kg**
- **Tower Steel tube model (mm):φ133×5**
- **Speed regulation: leaning tail + electric brake**
- **Capacity and quantity of battery: 12V100AH 18 pieces**
- **Can supply power for: Refrigerators, Water pumps, Cookers, Color TV sets, Washing machines, Lighting, Electric fans, and Charge**

DESCRIPTION

3KW Wind Generator,

3KW Wind Generator Feature:

- Magnetic saturation generator design, 20 years designed lifetime.
- 3m/s start-up wind speed under Low–torque start-up technique. 3. Mechanical automatic yawing.
- Matched controller with PWM constant voltage charging, electronic and manual brake, and numeral panel display.
- Special wind blades design can reach max rotor power coefficient.
- Supporting off grid and grid tie wind power system.

3KW Wind Generator **Specification:**

Rated Power (W)	3000W
Max Power (W)	4000W
Rated Voltage (DCV)	240V
Rated Current (A)	12.5A
Efficiency	85%
Output Voltage of Inverter	Single phase 110V-120V 60HZ or 220-240VAC/50HZ
Rotor Diameter(m)	4.5m
Start-up Wind Speed(m/s)	3m/s
Direction (Looking Downwind)	Counterclockwise
Location Relative to Tower	Downwind (Upwind Optional)
Rated Wind Speed(m/s)	10m/s
Security Wind Speed(m/s)	45m/s
Protection Mode	Dump load
Rated Rotation Speed(r/m)	300r/m
Shell Material	Aluminum Alloy
Blade Material	GFRP
Blade Quantity	3pcs
Guy-Cable Tower	12m

Free-Standing Tower	12m
Hydraulic Tower	12m
Suggested Battery Capacity	12V100Ah 20 pcs
Control System	Controller and Pure Sine Wave Inverter
Standard Supply Scope	Wind Turbine including turbine, hub, controller, off grid inverter, blades, tower, cables, accessories
Turbine Life Span	Around 20 years under normal wind Conditions

4. SOFTWARE OVERVIEW

4.1 METHODOLOGY

Modeling and analysis of 3-D models of the wind blade were carried out using ANSYS software and also mechanical properties of this wind blade were carried out. Also notches were created on the wind blade model and the best material which is conclude by the ansys results

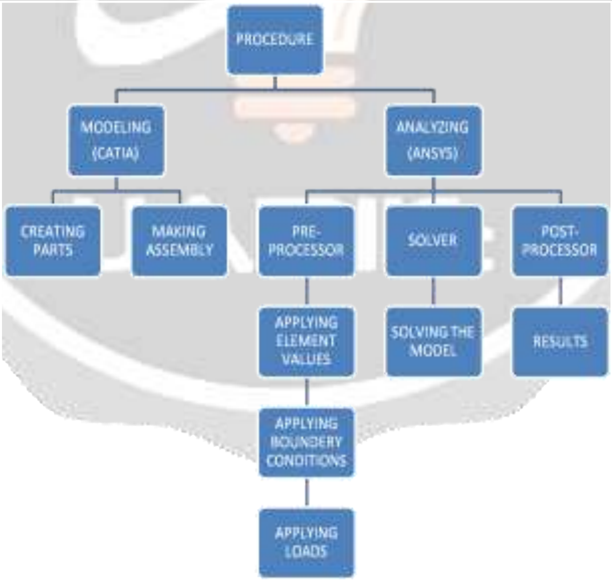


Fig. 4.1 Flow Chart

5. DESIGN & MODELING

5.1 Calculation for Energy Output

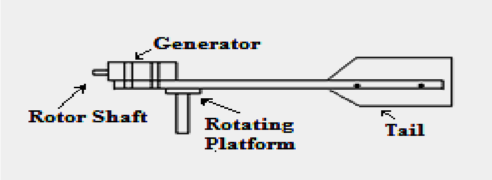


Fig. 5.1 Rough Sketch of Wind Turbine Arrangement

$K.E = 1/2 \ast m \ast V^2$
Where:
m = mass (kg)
V = velocity (m/s)
Note: In our area we get average wind velocity is 3-8 m/sec. & humidity is 30%
Usually, we're more interested in power (which changes moment to moment) than energy. Since
Energy = Power ∗ Time

And density is a more convenient way to express the mass of flowing air; the kinetic energy equation can be converted into a flow equation. Power in the area swept by the wind turbine rotor :
$P=1/2 \ast \rho \ast A \ast V^3$
Where: P = power in watts (746 watts = 1 hp) & (1,000 watts =1kilowatt)

ρ = air density (about 1.225 kg/m3 at sea level, less higher up)

A = rotor swept area, exposed to the wind (m2)

V = wind speed in m/s This yields the power in a free flowing stream of wind.

Of course, it is impossible to extract all the power from the wind because some flow must be maintained through the rotor (otherwise a brick wall would be a 100% efficient wind power extractor). So, we need to include some additional terms to get a practical equation for a wind turbine.

Wind Turbine Power : $P=1/2 \ast \rho \ast A \ast Cp \ast V^3 \ast Ng \ast NB$

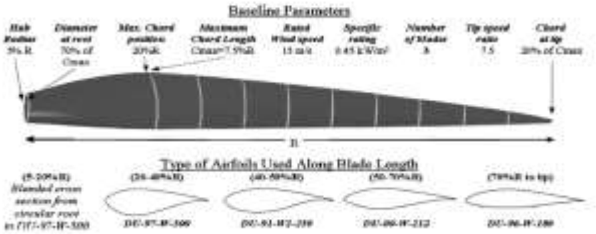
Where: P = power in watts (746 watts = 1 hp) & (1,000 watts = 1 kilowatt)
ρ = air density (about 1.225 kg/m3 at sea level, less higher up)
A = rotor swept area, exposed to the wind (m2)
Cp = Coefficient of performance (.59 {Betz limit} is the maximum theoretically possible, .35 for a good design)
V = wind speed in m/s
Ng = generator efficiency (50% for car alternator, 80% or possibly more for a permanent magnet generator or grid-connected induction generator)
Nb = gearbox/bearings efficiency (depends, could be as high as 95% if good) [4, 5] Tip Speed ratio for wind turbines is the ratio between the tangential speed of the tip of a blade and the actual velocity of the wind.$\lambda=r\omega/v$

Where: λ= Tip speed ratio

r= Radius of rotor

v =wind velocity

MODELING



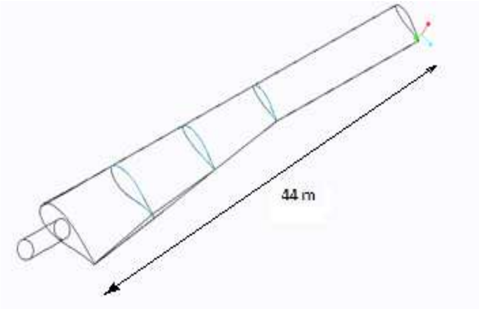


Fig. 5.2

Fig. 5.3

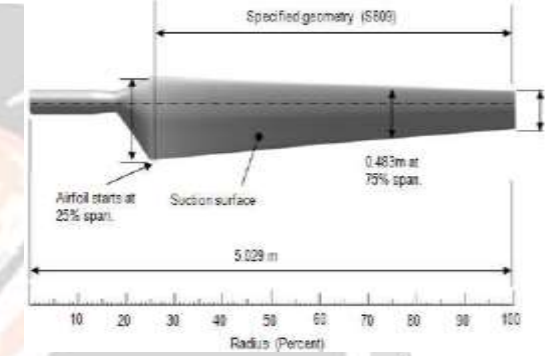


Fig. 5.4

Fig. 5.5

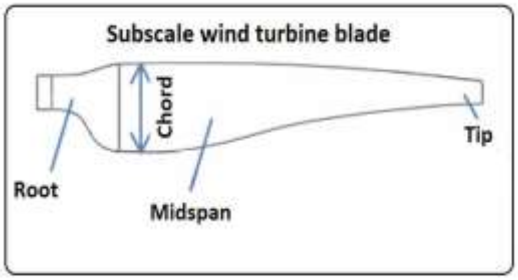


Fig.5.6

Fig. 5.7

Fig. 5.8

Fig. 5.9

Following blade profile are used for design and modeling in this projects,

- Blade Profile NACA-4412
- NACA(National Advisory Committee of Aeronautics)
- Root chord length -335 mm
- Tip chord length -136 mm
- Total length of the blade -2500 mm

It is a digit series of blade and 12 is indicate 12% of the thickness ratio related to chord it is symmetrical aero foil suitable for low speed operations.

6. ANALYSIS :

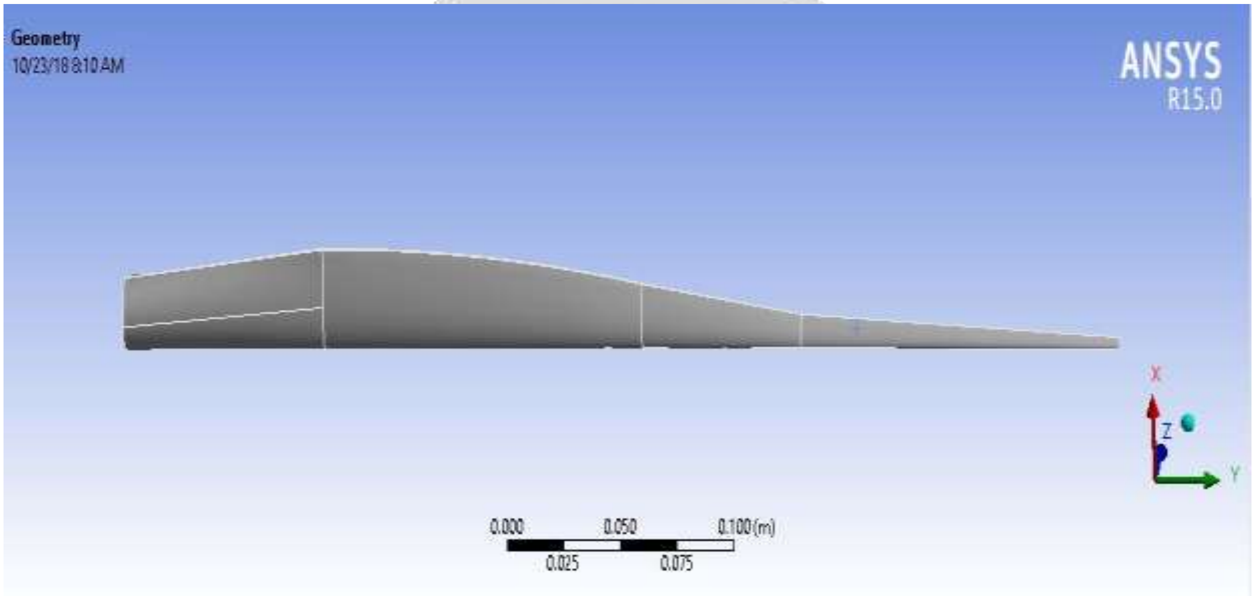
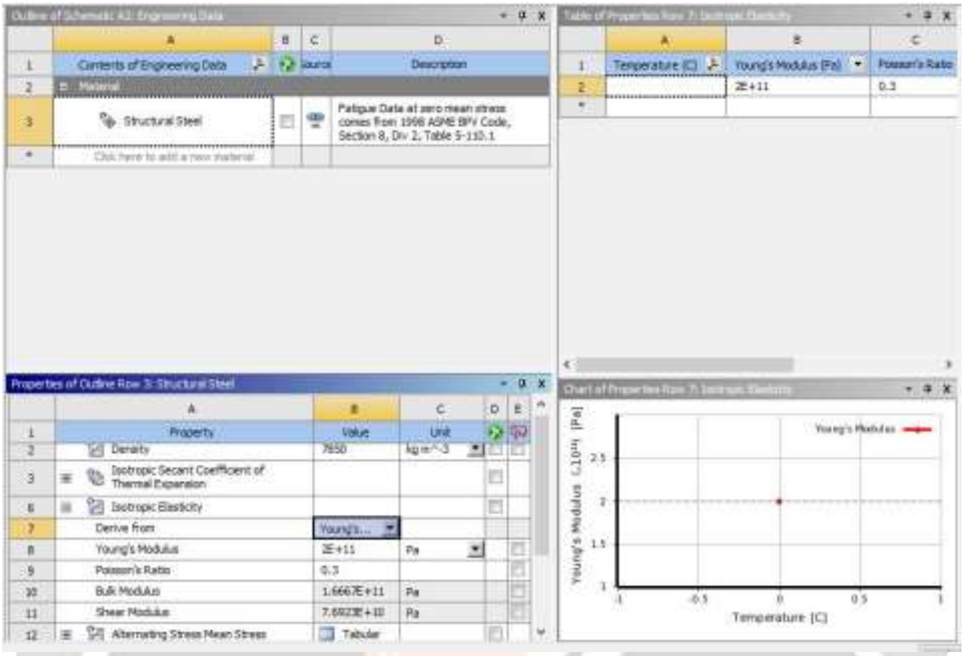


Fig. 6.1 Geometry

Boundary Condition:

Material	Properties		
	Density, ρ [kg/m³]	Modulus of Elasticity, E [N/mm²]	Poisson's ratio, υ
Structural Steel	7850	$2e^5$	0.3
Aluminum Alloy	2770	$7.1e^5$	0.33

Structural Steel



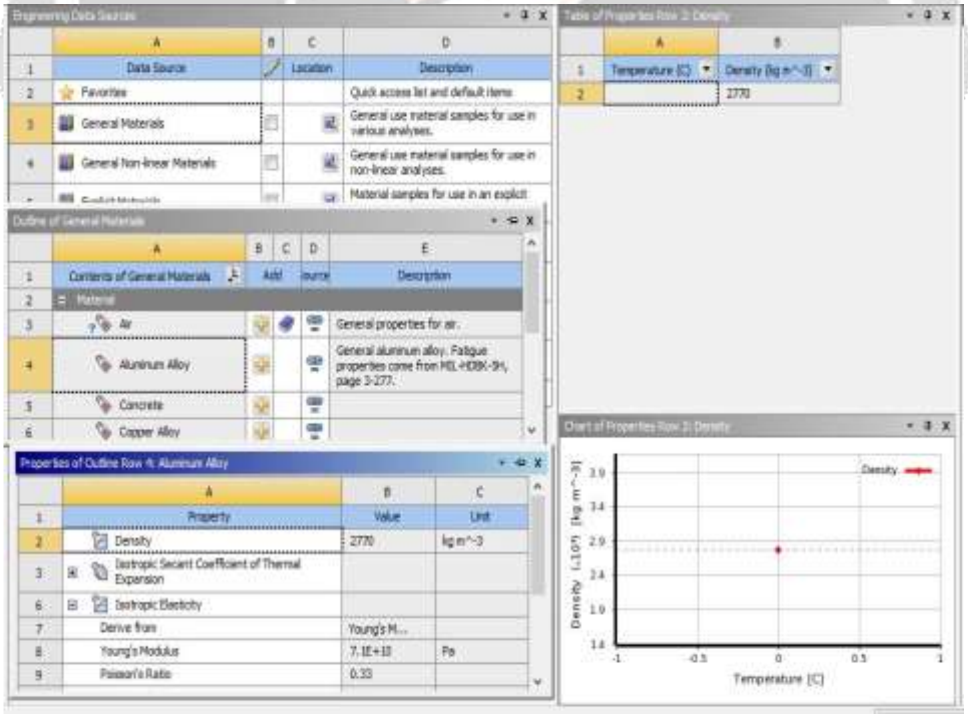
	A	B	C	D
1	Contents of Engineering Data		Source	Description
2	Material			
3	Structural Steel	☐		Fatigue Data at zero mean stress comes from 1998 ASME BPV Code, Section 8, Div 2, Table 5-110.1
*	Click here to add a new material			

	A	B	C
1	Temperature (C)	Young's Modulus (Pa)	Poisson's Ratio
2		2E+11	0.3
*			

	A	B	C	D	E
1	Property	Value	Unit		
2	Density	7850	kg m^-3	☐	☐
3	Isotropic Secant Coefficient of Thermal Expansion			☐	
6	Isotropic Elasticity			☐	
7	Derive from	Young's...			
8	Young's Modulus	2E+11	Pa		☐
9	Poisson's Ratio	0.3			☐
10	Bulk Modulus	1.6667E+11	Pa		☐
11	Shear Modulus	7.6923E+10	Pa		☐
12	Alternating Stress Mean Stress	Tabular		☐	

Chart 6.1 structural steel

Aluminum Alloy



	A	B	C	D
1	Data Source		Location	Description
2	Favorites			Quick access list and default items
3	General Materials	☐		General use material samples for use in various analyses.
4	General Non-linear Materials	☐		General use material samples for use in non-linear analyses.
				Material samples for use in an explicit

	A	B
1	Temperature (C)	Density (kg m^-3)
2		2770

	A	B	C	D	E
1	Contents of General Materials	Add		Source	Description
2	Material				
3	Air				General properties for air.
4	Aluminum Alloy				General aluminum alloy. Fatigue properties come from MIL-HDBK-5H, page 3-277.
5	Concrete				
6	Copper Alloy				

	A	B	C
1	Property	Value	Unit
2	Density	2770	kg m^-3
3	Isotropic Secant Coefficient of Thermal Expansion		
6	Isotropic Elasticity		
7	Derive from	Young's M...	
8	Young's Modulus	7.1E+10	Pa
9	Poisson's Ratio	0.33	

Chart 6.2 Aluminum Alloy

Analysis Result:

Material	Properties	
	Von-Mises Stress [Pa]	Deflection(mm)
Structural Steel	1880.5	0.066 e-3
Aluminum Alloy	1779	0.186 e-3

Table no 6.1 Analysis Result

Structural Steel

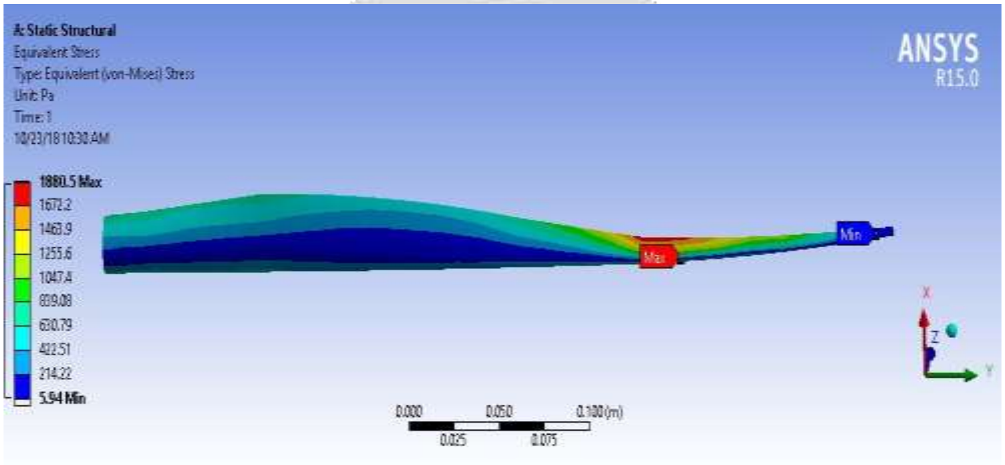


Fig 6.2 structural steel

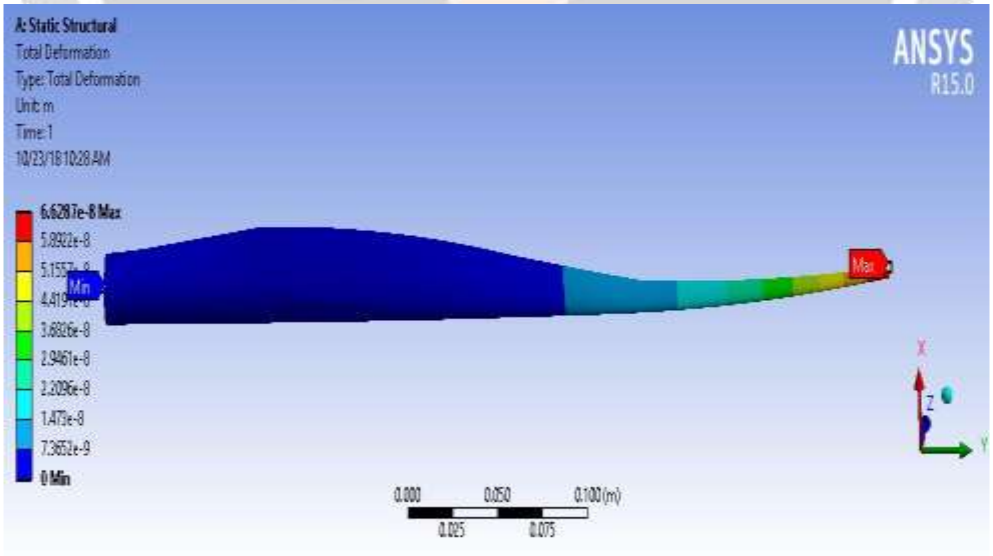


Fig 6.3 structural steel

Aluminum Alloy

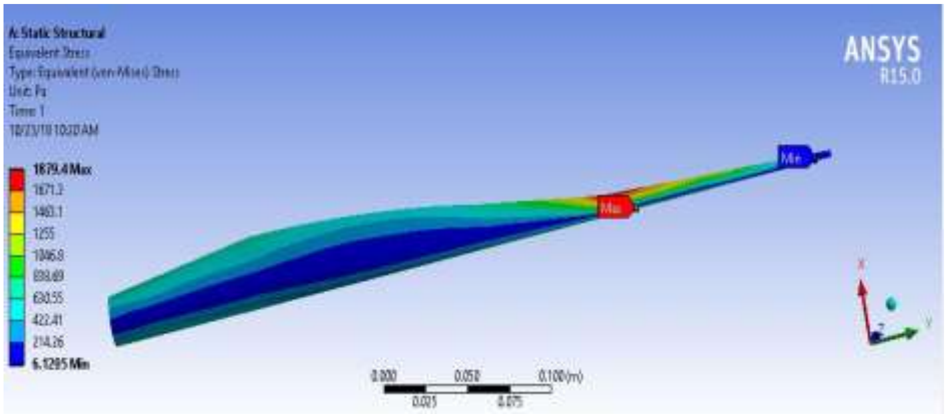


Fig 6.4 Aluminum Alloy

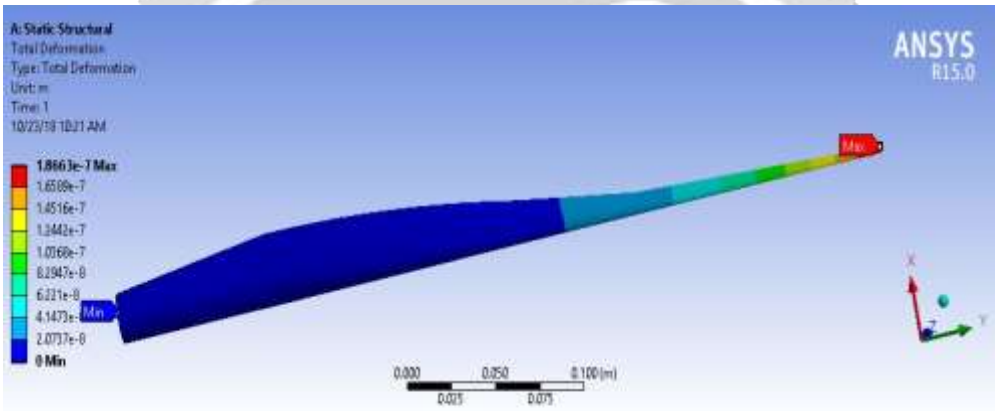


Fig 6.5 Aluminum Alloy

7. CONCLUSIONS

Small wind energy conversion systems are an effective, environmentally friendly power source for household and other applications. Although they are subject to climatic behavior and do not always deliver a constant supply of energy, they can be adapted to energy storage units that allow the selective distribution of the energy once it has been converted.

All modern wind turbines use lift force to create rotational motion in order to drive their gearbox and generator. For electrical energy generation high rotor speeds are favorable as they reduce the gearbox ratio required to achieve the generator's optimum operating speed.

Low solidity rotors ensure high rotational speeds are generated, however a rotor must also produce enough torque to overcome the drive train and generator losses. Three bladed turbines are of the most suitable solidity for a broad range of wind speeds and are the most frequently employed as mechanical/electrical converters.

8. REFERENCES

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