Modeling and Analysis of Wind Turbine Blade

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Abstract— Wind vitality is the vast majority of the promising sustainable power sources. Wind turbine is used to extract energy from wind. In wind turbine technology, turbine blade plays a significant role as it straight comes in contact through wind. Wind turbines, is same as that of Air vehicle with wings. The wings will help to create a lifting force to fly in air, similarly in wind turbine it will cause to rotate generator and conversion takes place from air energy into electrical energy. And also positive displacement machine, which is similar to fan. In the case of fan it will require electricity to run but in case of positive displacement machine it produces electricity via energy conversion. Positive displacement machine also known as wind turbine. The sharp edges assumes essential job by legitimately coming into contact with the outside air subsequently edge experiences worry because of connected weight. In this undertaking the breeze turbine cutting edge is planned in strong works 2016 structure programming and static investigation is completed in Ansys 16.0 work seat.

Keywords: FEM, Ansys 16.0

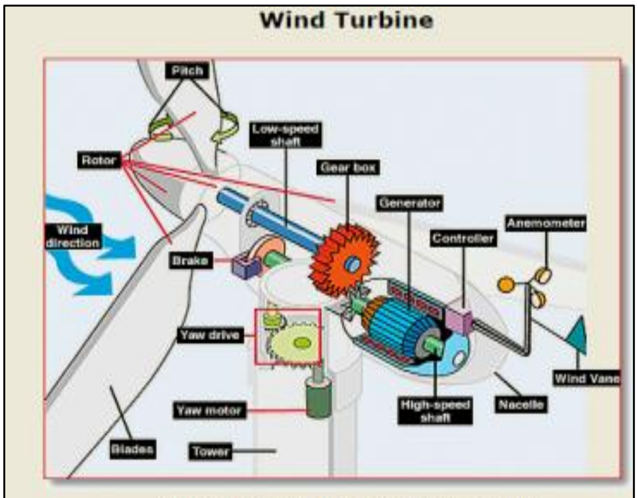
I. INTRODUCTION

Wind vitality is the vast majority of the promising sustainable power sources. Wind turbine is used to extract energy from wind. In wind turbine technology, turbine blade plays a significant role as it straight comes in contact through wind. Wind turbines, is same as that of Air vehicle with wings. The wings will help to create a lifting force to fly in air, similarly in wind turbine it will cause to rotate generator and conversion takes place from air energy into electrical energy. And also positive displacement machine is the which is similar to fan. In the case of fan it will require electricity to run but in case of positive displacement machine it produces electricity via energy conversion. Positive displacement machine also known as wind edge turbine. The sharp edges assume essential job by legitimately coming into contact with the outside air subsequently experiences worry because of connected weight.

II. WIND TURBINE

Wind turbines, like flying machine propeller front lines, turn in the moving air and power an electric generator that arrangement an electric stream. Fundamentally communicated, a breeze turbine is something in opposition to a fan. As opposed to using capacity to make wind, like a fan, wind turbines use wind to make control. The breeze turns the sharp edges, which turn a shaft, which interfaces with a generator and makes control.

A. *Wind Turbine Components*



Wind turbine components (Source: NREL)

- Blade or rotor, which changes over the vitality in the breeze to rotational shaft vitality;
- A drive train, more often than excluding a gearbox and a generator;
- A tower that supports the rotor and drive train; and
- Other hardware, including controls, electrical links, and ground bolster gear, and interconnection gear.

B. *Wind Turbine Size & Power Rating*

Wind turbines are accessible in an assortment of sizes, and in this manner control evaluations. The biggest machine has cutting edges that range more than the length of a football field, stands 20 building stories high, and delivers enough power to control 1,400 homes. A little home-sized breeze machine has rotors somewhere in the range of 8 and 25 feet in breadth and stands upwards of 30 feet and can supply the power needs of an all-electric home or private venture. Utility-scale turbines go in size from 50 to 750 kilowatts. Single little turbines, underneath 50 kilowatts, are utilized for homes, media communications dishes, or water siphoning.

C. *Advantages & Disadvantages of Wind Turbine*

– A renewable, free in nature & non-pollute resource
– Environmental concern & cost
– Supply & transportation

III. FINITE ELEMENT METHOD

It is a numerical procedure for acquiring surmised answer for a wide assortment of designing issue. Demonstrating and limited component investigations are the two most prevalent building applications. This is credited to the way that the limited component strategy is maybe the most well-known numerical procedure for taking care of designing issues. The strategy is sufficiently general to deal with any unpredictable shape or geometry, any material properties, any limit condition and any stacking conditions. The consensus of the limited component strategy fits the examination necessity of today s complex building framework and outline, it is an effective plan instrument by which creators can perform parametric outline thinks about by considering different plan cases, break down them and can pick the ideal outline.

IV. TURBINE BLADE MATERIAL & TYPES

When all is said in done, perfect materials should meet the accompanying criteria for the following types of turbine areas;

Vertical turbine, Horizontal & Upwind turbine

- Wide accessibility and simple preparing to diminish cost and upkeep
- Low weight or thickness to decrease gravitational powers
- High solidarity to withstand solid stacking of wind and gravitational power of the sharp edge itself
- High weakness protection from withstand cyclic stacking
- High firmness to guarantee steadiness of the ideal shape and direction of the edge and freedom with the pinnacle
- High break durability
- The capacity to withstand ecological effects, for example, lightning strikes, moistness, and temperature

Most of current popularized wind turbine cutting edges are produced using fiber-fortified polymers (FRP's), which are composites comprising of a polymer grid and filaments. The long filaments give longitudinal solidness and quality, and the grid gives crack sturdiness, delaminating quality, out-of-plane quality, and firmness.

A. Material Selection for Wind Turbine

The best possible determination of material for the diverse piece of a machine is the primary goal in the creation of machine. For a structure engineer it is must that he be comfortable with the impact, which the assembling procedure and warmth treatment have on the properties of materials. The Choice of material for building purposes relies on the accompanying components:

- Availability of the materials.
- Suitability of materials for the working condition in administration
- The cost of materials.
- Physical and compound properties of material.
- Mechanical properties of material.

V. THEORETICAL CALCULATION

Calculation of Power Density of Wind (Power per Unit Area)

Ideal Power density of air (15 meter height is considered)

= ½ × air density × (velocity)^3 Watt/m2

Actual power density that will be converted to useful energy

- Coefficient of performance = Power density × [Cp× transmission losses × generator losses]

Considering losses

- Transmission losses (rotor to generator) =0.90
- Generator losses = 0.90

Overall loss factor = Cp× transmission losses × generator losses

Actual power density = W/m2

Annual energy density (useful) = Power density× no of hours per Year Wh/m2

By considering the capacity factor (30%)

Real annual energy density = Annual energy density (useful) × capacity factor Wh/m2

Calculation of Rotor (Blade) Size

Area of the rotor = Total annual energy

Required/Real annual energy density = m2

Radius of the rotor blade (R),

$\pi R^2 = m$

Design of Rotor Blade: Design of rotor blade of Prototype

Chord Length 'C' = m

Span of airfoil L = m

Velocity of the airfoil 'U'= 60 rpm × R m/s

Power Rating of Windmill

= Actual power density × area of rotor

= ½ × air density × (velocity) 3 × area of rotor watt

Tip Speed Ratio

TSR = ωR/V

Where,

ω– Angular speed in radians R

– Rotor blade radius in meter

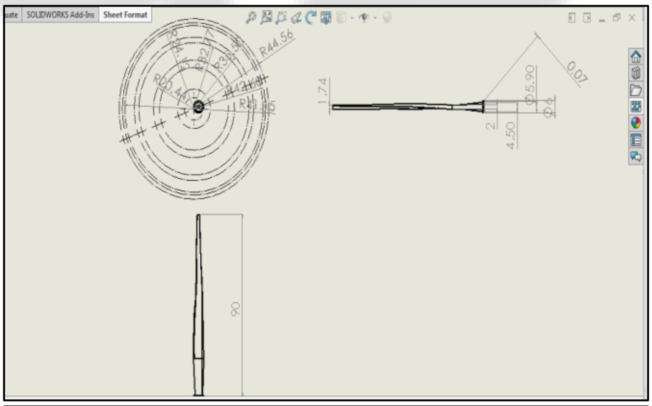
V – Wind Speed in m/s

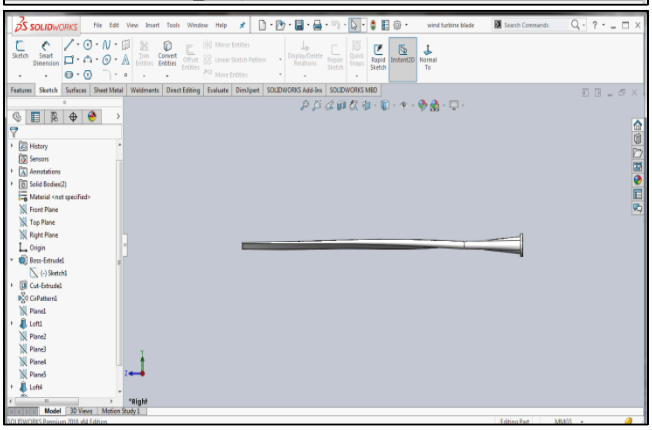
TSR = (2πN/60 * 1.25)/5

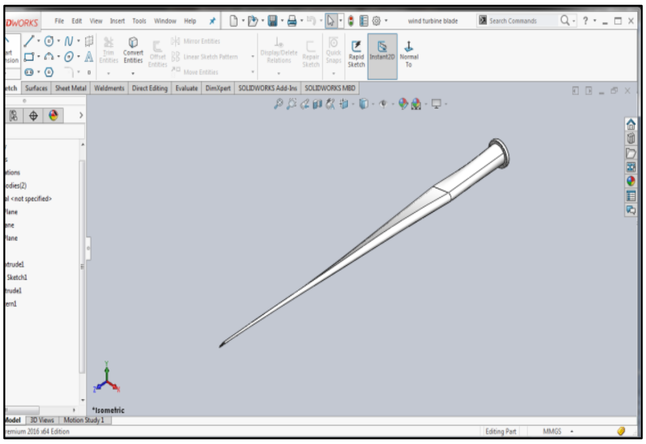
= (2π * R)/5

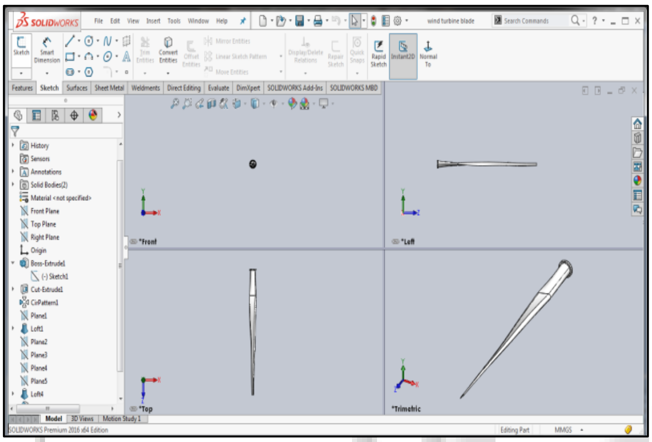
Number of blades would be 08 to 12.

A. Modeling of Wind Turbine Blade using Solid-Works CAD Modeling

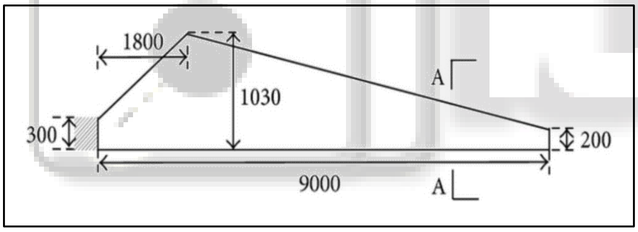








B. ANIYSIS 16.0

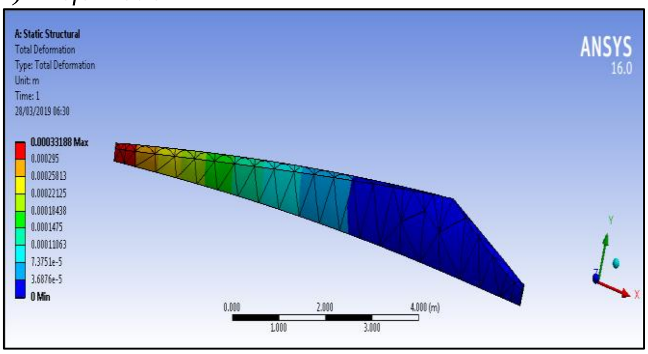


1) Material Properties

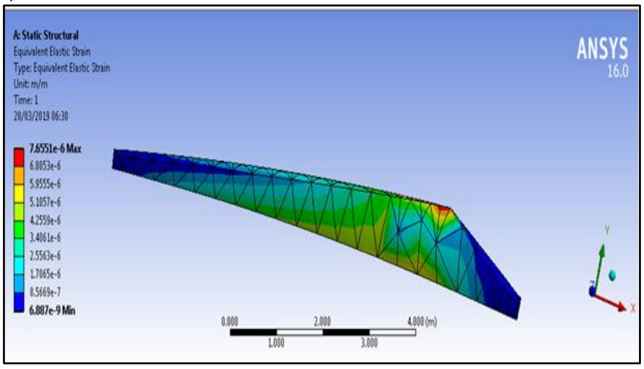
Material	Density (kg/m³)	Young's modulus (Pa)	Poison's ratio	Bulk modulus (Pa)	Shear modulus (Pa)
Aluminum alloy	2770	7.1E+10	0.33	6.9608E+10	2.6692E+10
Titanium alloy	4620	9.6E+10	0.36	1.1429E+10	3.5294E+10
Magnesium alloy	1800	4.5E+10	0.35	5E+10	1.6667E+10

Consider Titanium Alloy,

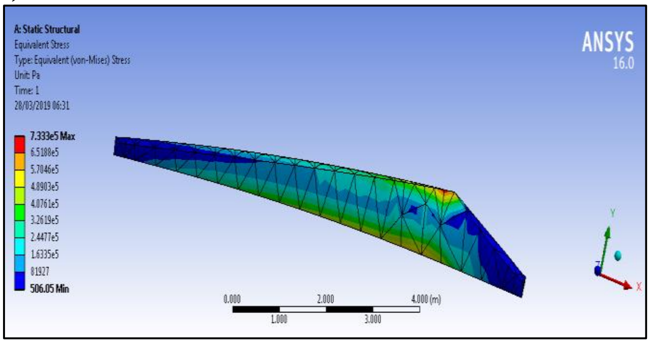
2) Deformation



3) Strain



4) Stress



C. Result

Material	Maximum stress	Total deformation	Maximum strain
Aluminum alloy	47190	1466	0.67038
Titanium alloy	47101	1079.9	0.49503
Magnesium alloy	47133	2307.1	1.0567

VI. CONCLUSION

- Modeling and analysis of wind turbine blade is done
- Modeling of turbine blade is done using solid works 2016 design software.
- Modeling of turbine blade- is done using catia v5 design software.
- File is converted as IGS and is imported to Ansys
- Static analysis of blade- is carried out at 3mpa pressure by assigning three different materials such as aluminum alloy, titanium alloy and magnesium alloy.
- Stress, deformation values are studied.
- From the results we can conclude that generally titanium alloys are used for the turbine blades here magnesium alloy got the less stress value which is nearer to the titanium hence magnesium is the preferable material.

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