DESIGN AND ANALYSIS OF WIND TURBINE

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Certificate

This is to certify that the minor project titled **ANALYSIS OF WIND TURBINE** is a Bona Fide work carried out by

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In partial fulfilment of the requirements for the award of degree Bachelor of Engineering in Mechanical Engineering by the National Institute of Engineering, during the year 2020-21.

This report has been approved in partial fulfilment for the award of the said degree as per academic regulations of The National Institute of Engineering (An Autonomous Institute under VTU)

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ABSTRACT

The world is running out of conventional energy sources and there is a pressing need of utilizing non-traditional energy sources to endure the everescalating energy needs. Wind turbines provide an alternative way of generating energy from the power of wind. At windy places, wind speeds can achieve scintillating values of 10-12 m/s. Such high speeds of wind can be utilized to harness energy by installing a wind turbine usually having 3 blades. The geometry of the blades is made as such that it generates lift from the wind and thus rotates. The lift force generates a moment around the hub and thus the combined torque effort of 3 blades rotates the turbine and generates electricity. Rotational speed of the blades is usually 6 times that of wind speed. In the design of modern wind turbines, advances in materials, engineering, electronics and aerodynamics are considered. Several wind turbines are often grouped together as a wind farm, and generate bulk electrical power. The electricity generated from these turbines is fed into the local utility grid and is distributed to customers to meet the national and regional energy demand. This project describes about the principle and working of wind turbine as they are becoming popular in the renewable energy world. Primary objective in wind turbine design is to maximize the aerodynamic efficiency, or power extracted from the wind. The blade is designed using different types of airfoils which are oriented at different angle of attack and the blade design is responsible for the efficiency for the wind turbine. The Wind turbine is designed by Ug NX software and Structural analysis is performed by ANSYS WORKBENCH software and FLUENT solver.

1.INTRODUCTION

One of the major challenges in this new century is the production of energy as well as the efficient use of energy from renewable energy sources. The terms wind energy or wind power describes the process by which the wind is used to generate mechanical power or electricity. Wind turbines convert the kinetic energy in the wind into mechanical power. This mechanical power can be used for specific tasks (such as grinding grain or pumping water) or a generator can convert this mechanical power into electricity. A wind turbine works the opposite of a fan. Instead of using electricity to make wind, like a fan, wind turbines use wind to make electricity. A wind turbine is a device that converts kinetic energy from the wind into electrical power. Wind turbines operate on a simple principle. The energy in the wind turns two or three propeller-like blades around a rotor. The rotor is connected to the main shaft, which spins a generator to create electricity.

1.1) Changing winds: The Evolution

As early as the first century A.D., wind energy was harnessed for practical purposes. Since then, turbine designs have come a long way from the archetypal post-mounted four-bladed devices. Today's ubiquitous three-bladed designs will soon be evolving in many unexpected directions.1st century AD: For the first time in known history, a wind-driven wheel is used to power a machine. A Greek engineer, Heron of Alexandria, creates this wind wheel. By 7th to 9th century: Wind wheels are used for practical purposes in Iran, near Afghanistan. The panemone windmills are used to grind corn, grind flour, and pump water. By 1000 AD: Windmills are used for pumping seawater to make salt in China and Sicily.1180s: Vertical windmills are used in Northwestern Europe for grinding flour.1887: The first known turbine used to produce electricity is built in Scotland. The wind turbine is created by Prof James Blyth of Anderson's College, Glasgow (now known as Strathclyde University). "Blyth's 10 m high, cloth-sailed wind turbine was installed in the garden of his holiday and was used to charge accumulators developed by the Frenchman Camille Alphonse Faure, to power the lighting in the cottage, thus making it the first house in the world to have its electricity supplied by wind power. Blyth offered the surplus electricity to the people for lighting the main street, however, they turned down the offer as they thought electricity was 'the work of the devil.'

2) Literature Survey

G.W. gyatt NASA (1986) carried out the field testing of vortex generators on Carter Model 25 wind turbine. A generalized relation between different parameters of vortex generators for the wind turbine was obtained. From the study, it was concluded that the vortex generators performed well above for a wind speed of 10m/s and also the vortex generators on the outboard span of the wind turbine contributed more for the performance improvement.

Anders Ahlstrom (2005) developed a finite element model for simulation of the dynamic response of horizontal axis wind turbines. The developed model uses the commercial finite element system MSC. Marc, focused on nonlinear design and analysis, to predict the structural response. The aerodynamic model, used to transform the wind flow field to loads on the blades, is a Blade Element Momentum model. The verification of the model with measurements showed that the models successfully predict the response in normal as well as in more extreme load cases.

3) TYPES OF TURBINES

There are many types of wind turbines. The efficiency of each wind turbine type varies by its design and fabrication. For example, in agricultural farms, wind turbine is designed to obtain maximum torque, to pump water or to grind grains. In case of power generation, the wind turbines are designed to maximize the power output.

3.1) HORIZONTAL AXIS

Horizontal axis wind turbines are the most common type used (figure1). All of the components (blades, shaft, generator) are on top of a tall tower, and the blades face into the wind. The shaft is horizontal to the ground. The wind hits the blades of the turbine that are connected to a shaft causing rotation. The shaft has a gear on the end which turns a generator. The generator produces electricity and sends the electricity into the power grid. The wind turbine also has some key elements that adds to efficiency. Inside the Nacelle (or head) is an anemometer, wind vane, and controller that read the speed and direction of the wind. As the wind changes direction, a motor (yaw motor) turns the nacelle so the blades are always facing the wind. The power source also comes with a safety feature. In case of extreme wind the turbine has a break that can slow the shaft speed. This is to inhibit any damage to the turbine in extreme conditions.

Advantages:

• Blades are to the side of the turbines center of gravity, helping stability

• Ability to wing warp, which gives the turbine blades the best angle of attack

• Ability to pitch the rotor blades in a storm to minimize damage

Disadvantages:

• Difficulty operating in near ground winds

• Difficult to transport (20% of equipment costs)

3.2) VERTICAL AXIS

In vertical axis turbines the shaft the blades are connected to is vertical to the ground . All of the main components are close to the ground. Also, the wind turbine itself is near the ground, unlike horizontal where everything is on a tower. There are two types of vertical axis wind turbines; lift based and drag based. Lift based designs are generally much more efficient than drag, or ‘paddle’ designs.

Advantages

• Easy to maintain
• Lower construction and transportation costs
• Not directional
• Most effective at mesas, hilltops, ridgelines and passes

Disadvantages

• Blades constantly spinning back into the wind causing drag
• Less efficient

Horizontal wind turbines are the most commonly used types, hence the same has been considered for study

3.3) CLASSIFICATION OF HAWT

HAWT are classified as shown in (Table 1) below according to their diameters and /or their rated powers.

Table 1

Scale	Rotor Diameter	Power Rating
small	Less than 12m	Less than 40KW
Medium	12m to 45m	40KW to 999KW
Large	46m and larger	1MW and larger

In Figure 1, scales of HAWT are given for the prescribed rated capacity to provide better understanding the relation between the rated capacities of a HAWT with its rotor diameter and tower height.

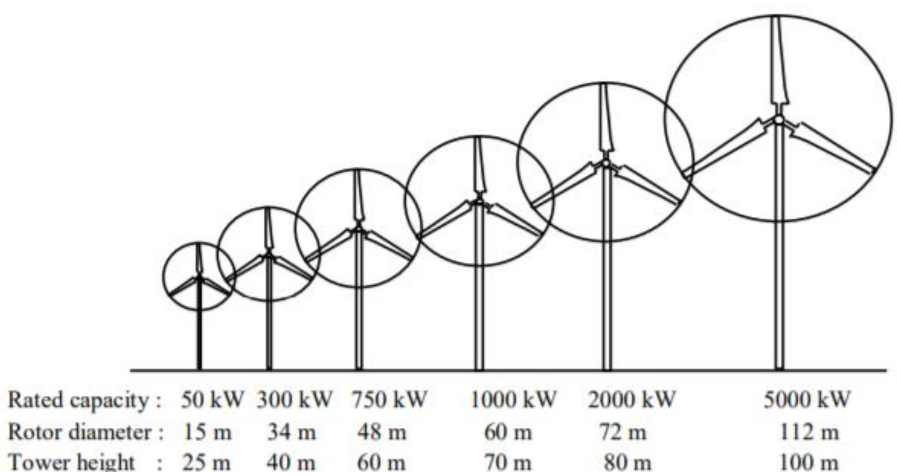


Figure 1

4) AIRFOILS FOR TURBINE BLADES

Modern HAWT blades have been designed using airfoil 'families' (Hansen and Butterfield, 1993). The blade tip is designed using a thin airfoil, for high lift to drag ratio, and the root region is designed using a thick version of the same airfoil for structural support. Generally, in the 1970's and early 1980's, wind turbine designers felt that minor differences in airfoil performance characteristics were far less important than optimizing blade twist and taper. Thus, airfoils that were in use by the aircraft industry were chosen because aircraft were viewed as similar applications.

Aviation airfoils such as the NACA 44xx and NACA 230xx were popular airfoil choices because they had high maximum lift coefficients, low pitching moment, and minimum drag. In the early 1980's, wind turbine designers became aware of airfoils such as the NASA LSMOD, and this airfoil was chosen by US and British designers for its reduced sensitivity to leading edge roughness, compared to the NACA 44xx and NACA 230xx series airfoils Danish wind turbine designers began to use the NACA 63(2)- xx instead of the NACA 44xx airfoils for the same reasons.

4.1) *Blade Nomenclature*: Typical airfoil can be divided into four sections: the leading edge, trailing edge, upper surface or suction side, and lower surface or pressure side. The line connecting leading edge with trailing edge is called the chord line. The curve that passes through midway pint of the upper surface and the lover surfaces of an airfoil is called mean camber line. The thickness of an airfoil is defined the maximum distance between airfoil's upper surface and lower surface and it is generally provided as a fraction of the chord length.

<u>4.12) Lift and drag forces:</u> The airflow through an airfoil is distributed unevenly and produces forces on the airfoil surface. The lift force is obtained the when there is a pressure difference of the air between upper surface region and the lower surface region of an airfoil, and it is perpendicular to the relative wind flow. Drag force is the parallel to flow direction, and it is also created form unequal pressure on the airfoil surfaces facing forward and away from the

oncoming flow. Both lift and drag forces result the thrust and torque to the system and their ratio defines one of the key characteristics of an airfoil. The lift force is a beneficial force, which needs to be increased, and the drag force needs to be as much as smaller in order to get high lift to drag ratio.

4.13) Turbulent vs. laminar flow**:** When airflow with no disruption and smooth streamline is called laminar flow. The particles of the air move parallel layer. In turbulent flow, the fluctuations cause the particles of the air to get mixed and move through the layers. as a result they get high and low kinetic energy, giving a much more uniform velocity profile. Also, turbulent flow has higher friction and lower tendency to separate

4.14) Angle of attack, stall, and separation: Angle of attack is defined the angle between chord line of an airfoil and the relative wind. The angle of attack can be negative or positive depending on the position and shape of an airfoil. When the flow is no longer manages to stay attached to the surface the separation will occur, where there will be a layer of reversed flow close to the surface, and oncoming flow will be pushed away. As the angle of attack increases the drag and lift force increases up to a point when the lift decreases abruptly and drag becomes a principle component. This angle called a stalling angle and from this angle the drag starts to increase dramatically reducing the lift.

4.15) Tip speed ratio**:** Tip speed is defined as the product of the rotors speed and the rotor radius. The ratio between the tip speed and the wind speed is called tip speed ratio. The optimum values of tip speed ratio are typically in range between 5 to 10.

4.16) Reynolds number: One of the important parameter for every airfoil is its operating Reynolds number. The performance characteristics of an airfoil are expressed as a function of Reynolds number, and it significantly affects the values of airfoil drag and lift characteristics. The general level of the drag coefficient increases with decreasing Reynolds number. Also, as the length of the blade decreases, the blade’s Reynolds number also tends to decrease.

4.27) Insensitivity to roughness: Leading edge roughness of an airfoil causes aggregation of dirt, insect, or ice on the surface, which brings serious issue and affects rotor power output. In extreme cases this can degrade the rotor power output as much as 40%

5) THE NACA AIRFOIL SERIES

The NACA airfoils are airfoil shapes for aircraft wings developed by the National Advisory Committee of Aeronautics (NACA). The shape of the NACA airfoils is described using a series of digits following the word "NACA. The early NACA airfoil series, the 4-digit, 5-digit, and modified 4-/5-digit, were generated using analytical equations that describe the camber of the mean-line of the airfoil section as well as the section's thickness distribution along the length of the airfoil. This methodology began to change in the early 1930s with the publishing of a NACA report entitled The Characteristics of 78 Related Airfoil Sections from Tests in the Variable Density Wind Tunnel. , the authors noted that there were many similarities between the airfoils that were most successful, and the two primary variables that affect those shapes are the slope of the airfoil mean camber line and the thickness distribution above and below this line. They then presented a series of equations incorporating these two variables that could be used to generate an entire family of related airfoil shapes.

5.1)NACA Four-Digit Series: The first family of airfoils designed using this approach became known as the NACA Four-Digit Series. The first digit specifies the maximum camber (m) in percentage of the chord (airfoil length), the second indicates the position of the maximum camber (p) in tenths of chord, and the last two numbers provide the maximum thickness (t) of the airfoil in percentage of chord. For example, the NACA 2415 airfoil has a maximum thickness of 15% with a camber of 2% located 40% back from the airfoil leading edge (or 0.4c).

5.2)NACA Five-Digit Series: The NACA Five-Digit Series uses the same thickness forms as the Four-Digit Series but the mean camber line is defined differently and the naming convention is a bit more complex. The first digit, when multiplied by 3/2, yields the design lift coefficient (cl) in tenths. The next two digits, when divided by 2, give the position of the maximum camber (p) in tenths of chord. The final two digits again indicate the maximum thickness (t) in percentage of chord.

6) ICE ACCRETION EFFECTS ON TURBINE BLADES:

Ice accretion on wind turbine blades is responsible for a significant increase in aerodynamic drag and decrease in aerodynamic lift and may even cause premature flow separation The following problems are directly related to icing and cold climate:

- Measurement errors:
- Power losses:
- Overproduction:
- Mechanical failures:
- Electrical failure:

7) WORKING PRINCIPLE OF WIND TURBINE

Windmill is to convert kinetic energy of wind into mechanical energy which is used to rotate the turbine of electrical generator to produce electricity.

7.1) Components and their functions

- The nacelle contains the key components of the wind turbine, including the gearbox, and the electrical generator. Service personnel may enter the nacelle from the tower of the turbine. To the left of the nacelle we have the wind turbine rotor, i.e. the rotor blades and the hub.
- The rotor blades capture the wind and transfer its power to the rotor hub. On a modern 1000 kW wind turbine each rotor blade measures about 27metres (80 ft.) in length.
- The hub of the rotor is attached to the low speed shaft of the wind turbine.
- The low speed shaft of the wind turbine connects the rotor hub to the gearbox. On a modern 1000 kW wind turbine the rotor rotates relatively slowly, about 19 to 30 revolutions per minute (RPM). The shaft contains pipes for the hydraulics system to enable the aerodynamic brakes to operate.
- The gear box has the low speed shaft to the left. It makes the highspeed shaft to the right turn approximately 50 times faster than the low speed shaft.

- The highspeed shaft rotates with approximately. 1,500 revolutions per minute (RPM) and drives the electrical generator. It is equipped with an emergency mechanical disc brake. The mechanical brake is used in case of failure of the aerodynamic brake, or when the turbine is being serviced.
- The electrical generator is usually a so-called induction generator or asynchronous generator. On a modern wind turbine the maximum electric power is usually between 600 and 3000 kilowatts (kW).
- The electronic controller contains a computer which continuously monitors the condition of the wind turbine and controls the yaw mechanism. In case of any malfunction, (e.g. overheating of the gearbox or the generator), it automatically stops the wind turbine and calls the turbine operator's computer via a telephone modem link.
- The hydraulics system is used to reset the aerodynamic brakes of the wind turbine.
- The cooling unit contains an electric fan which is used to cool the electrical generator. In addition, it contains an oil cooling unit which is used to cool the oil in the gearbox. Some turbines have water-cooled generators.
- The anemometer and wind wane are used to measure the speed and the direction of the wind. The electronic signals from the anemometer are used by the wind turbine's electronic controller to start the wind turbine when the wind speed reaches approximately 5 meters per second. The computers stops the wind turbine automatically if the wind speed exceeds 25 meters per second (50 knots) in order to protect the turbine and its surroundings.

7.2) *Yaw Mechanism*

The wind turbine yaw mechanism is used to turn the wind turbine rotor against the wind. The wind turbine is said to have a yaw error, if the rotor is not perpendicular to the wind. A yaw error implies that a lower share of the energy in the wind will be running through the rotor area. In contrast to the function of pointing the rotor swept area towards the wind direction for optimal power input, the yaw system can be used for power regulation above rated wind speeds. This is achieved by reducing the rotor swept area directed to the oncoming wind. A yaw system for rapid power regulation requires high yaw speeds as the decrease in power production in relation to the yaw error is small. Moreover the yaw torque has to overcome high yaw moments due to the large moment of inertia of the nacelle and the rotor.The yaw brakes apply a braking torque on the brake disc which is mounted between the tower flange and the yaw bearing. An even stress distribution on the flanks can be achieved by a convex/concave arrangement when the shaft pinions are engaged with an internal ring brake linings of the yaw brakes are wearing parts and have to be changed during the wind turbine lifetime it is favourable for an arrangement on the inner side of the tower for better accessibility.

8) BLADE DESIGN

Wind turbine rotor blade design typically includes airfoil selection, design of blade for optimum performance in wide range of flow conditions, determination of pitch angle of the blade and number of blades, design of connecting rods, shaft of the rotor and hub of the rotor. Using the UG NX software we have designed a small wind turbine of swept area 314.159sq.m. The goal is to generate power between the range of 20-40kW. The length of each blade in this three-blade horizontal axis wind turbine is 4.8m. The airfoil is done using NACA 4415.

These are the specifications used to construct this blade. The specification are shown in table 2 below

Figure 2- Ug Nx wind turbine model

Table 2

CHORD LENGTH IN m	PITCH ANGLE IN DEGREE	RADIUS(r) IN m
0.5156	37.729	0.252
0.4508	17.38	0.756
0.317	9.214	1.26
0.238	5.230	1.764
0.1891	2.912	2.268
0.1565	1.429	2.772
0.1333	0.410	3.276
0.1159	-0.286	3.78
0.1026	-0.616	4.284
0.09196	2.166	4.788

The above provides values that make up a wind turbine blade as shown in an example below (figure 9)

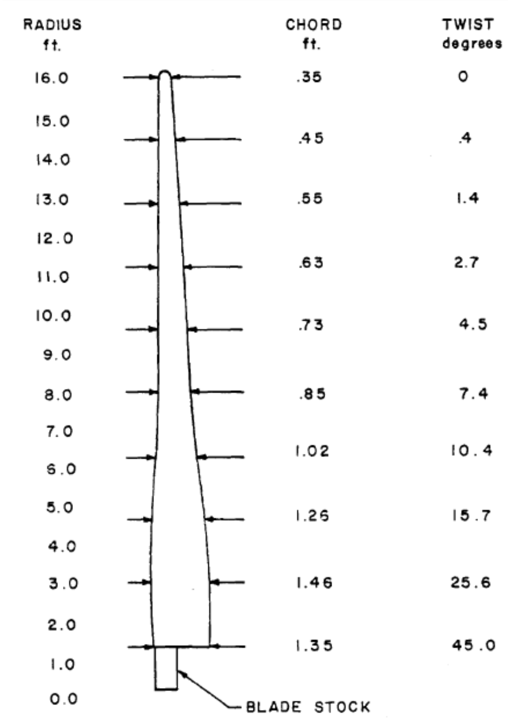


Figure 3

A German physicist Albert Betz concluded in 1919 that no wind turbine can convert more than 16/27 (59.3%) of the kinetic energy of the wind into mechanical energy turning a rotor. To this day, this is known as the Betz Limit or Betz' Law. The theoretical maximum power efficiency of any design of wind turbine is 0.59 (i.e. no more than 59% of the energy carried by the wind can be extracted by a wind turbine). This is called the "power coefficient" and is defined as: Cpmax = 0.59

Also, wind turbines cannot operate at this maximum limit. The Cp value is unique to each turbine type and is a function of wind speed that the turbine is operating in. Once we incorporate various engineering requirements of a wind turbine - strength and durability in particular - the real world limit is well below the Betz Limit with values of 0.35-0.45 common even in the best designed wind turbines. By the time we take into account the other factors in a complete wind turbine system - e.g. the gearbox, bearings, generator and so on - only 10-30% of the power of the wind is ever actually converted into usable electricity. Hence, the power coefficient needs to be factored in equation (4) and the extractable power from the wind is given by:

POWER= (1/2)Cp(V^3) ρ A

Where,
C_P is the power coefficient
ρ is the density of air
A is the swept area
V is the free stream velocity.

Calculations:

Blade length, l = 4.8m

Wind speed, v = 12 m/sec

Air density, ρ = 1.23 kg/m3

Power Coefficient, Cp = 0.4

Inserting the value for blade length as the radius of the swept area into equation (8) we have:

Area $A=\pi r^2=3.142 \times 4.8^2=72.38$ sq.m.

We can then calculate the power converted from the wind into rotational energy in the turbine using equation:

$P=(1/2)Cp(V^3)\,\rho\, A$

$=(1/2)\times0.4\times(12^3)\times1.23\times72.38$

$P = 30.76$ kW

The turbine designed can generate power of 30.76kW.

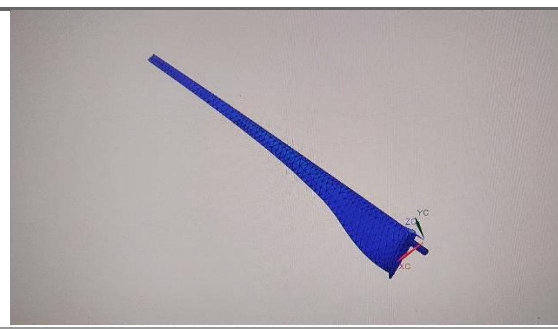
9) ANALYSIS

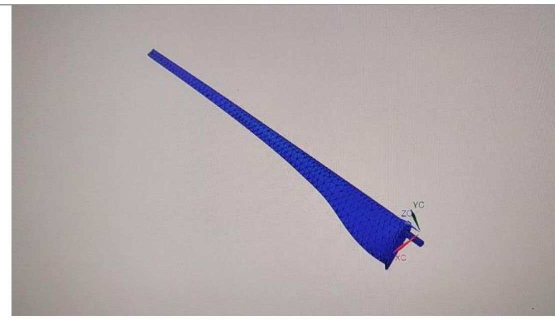
Analysis of generated model of wind turbine is done by UgNx software by which we get the results of stress distribution over blades, power generation by the turbine, velocity and turbulence effect by wind on the rotor blades.

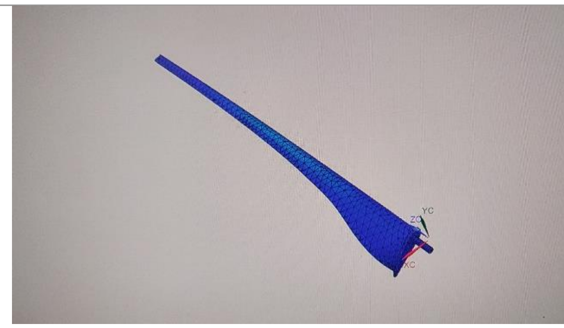
9.1) STRESS ANALYSIS

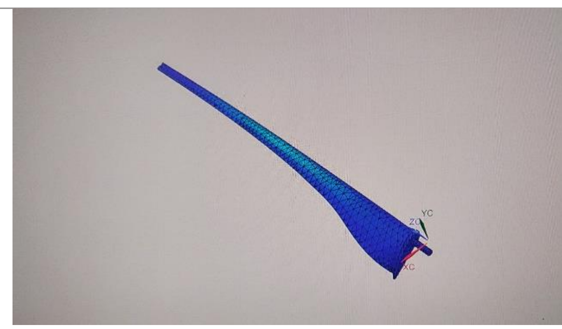
The blade designed for the wind turbine undergoes stress analysis and the result are shown (table 3)

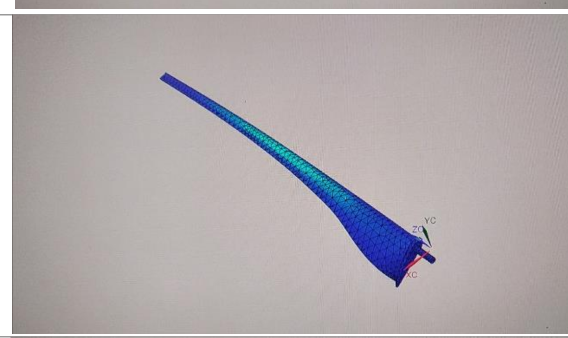
Table 3

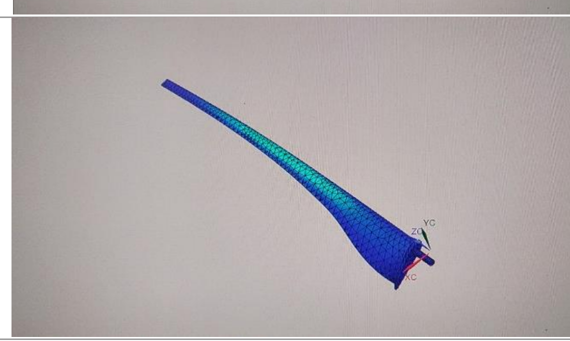
DISPLACEMENT	STRESS
	

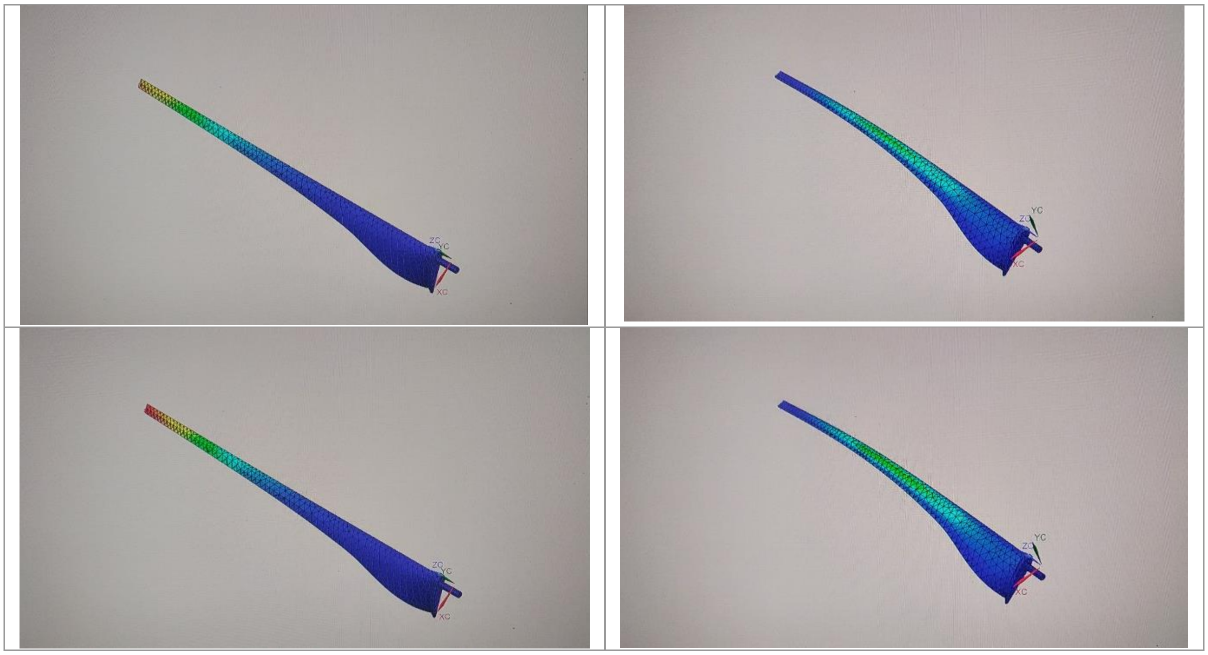











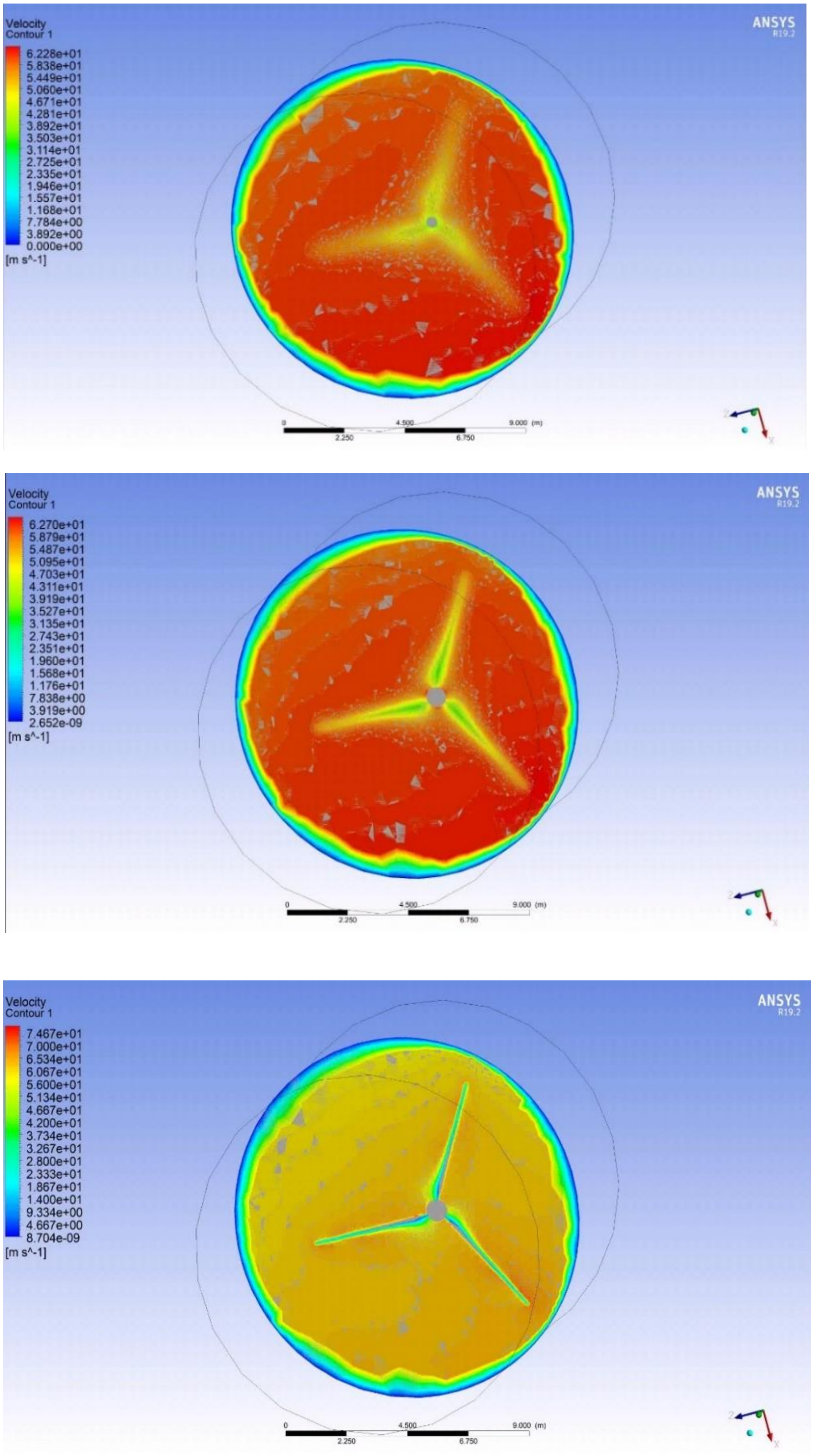


As the simulation shows in the table, the displacement and stress of the blade under load at their given respective time, act at different points. The displacement takes place more where the cross section of the blade is less, which is at the tip of the blade. But at the same time, stress is maximum at the middle of the blade. So this infers that both stress and displacement act at different parts of the blade at the same time.

<u>CFD ANALYSIS:</u>

9.2) VELOCITY ANALYSIS OVER ROTOR BLADES:

When high speed wind comes in contact with the turbine, it transfers its kinetic energy onto the wind turbine blades, which rotate to generate power. This transfer leads to decrease in the velocity around the blades. When observed closely, even after the impact of high speed wind, the air at the corner of the trialing edge travels at high velocity, which demonstrates the aerodynamics of the airfoil shaped blades. This is the reason why lift is generated and leads to the rotation of the blades as shown below.


Velocity
Contour 1
6.228e+01
5.838e+01
5.449e+01
5.060e+01
4.671e+01
4.281e+01
3.892e+01
3.503e+01
3.114e+01
2.725e+01
2.335e+01
1.946e+01
1.557e+01
1.168e+01
7.784e+00
3.892e+00
0.000e+00
[m s^-1]
ANSYS
R19.2
0
4.500
9.000 (m)
2.250
6.750
Velocity
Contour 1
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5.487e+01
5.095e+01
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9.000 (m)
2.250
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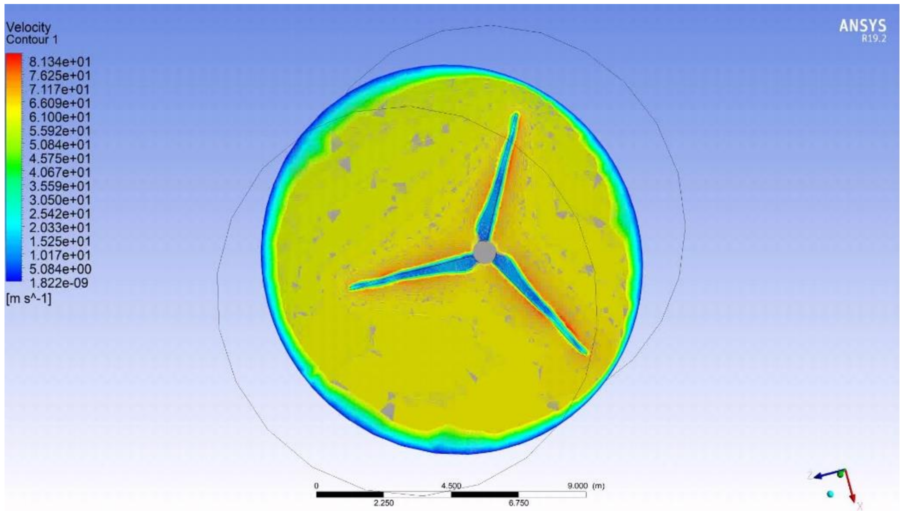
Fig.4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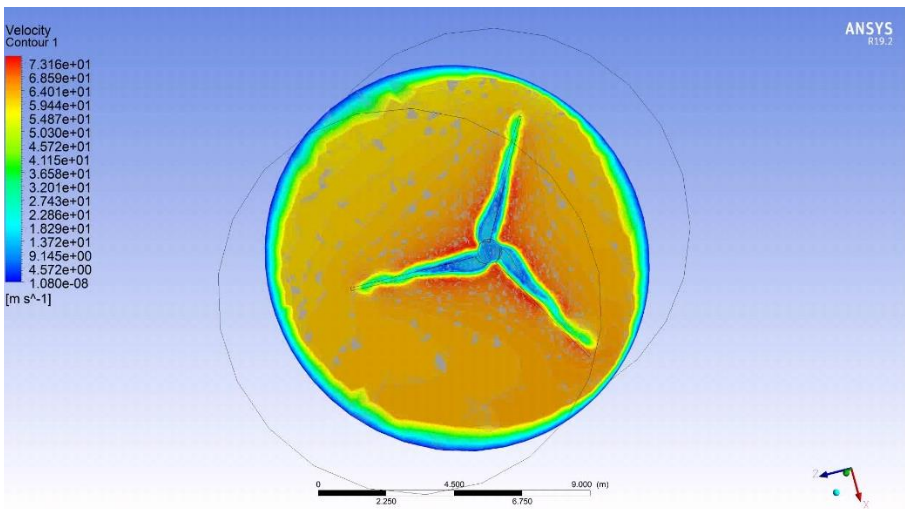
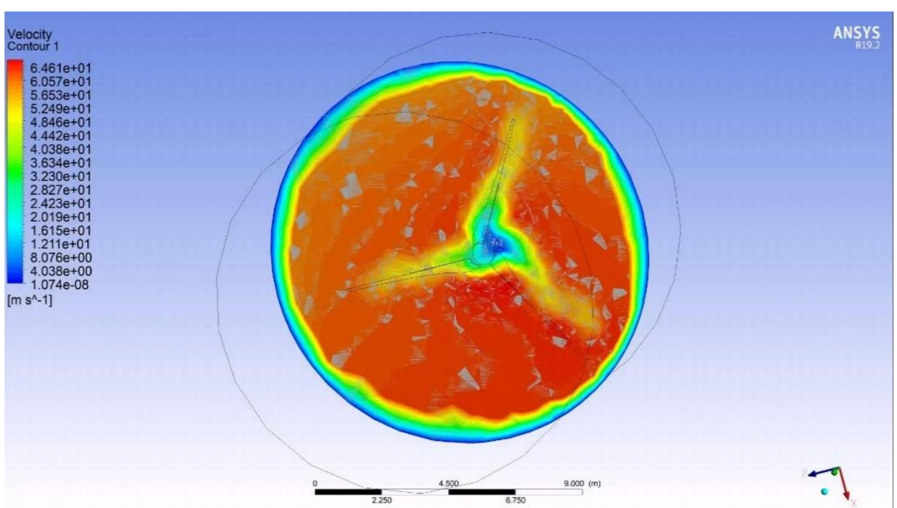
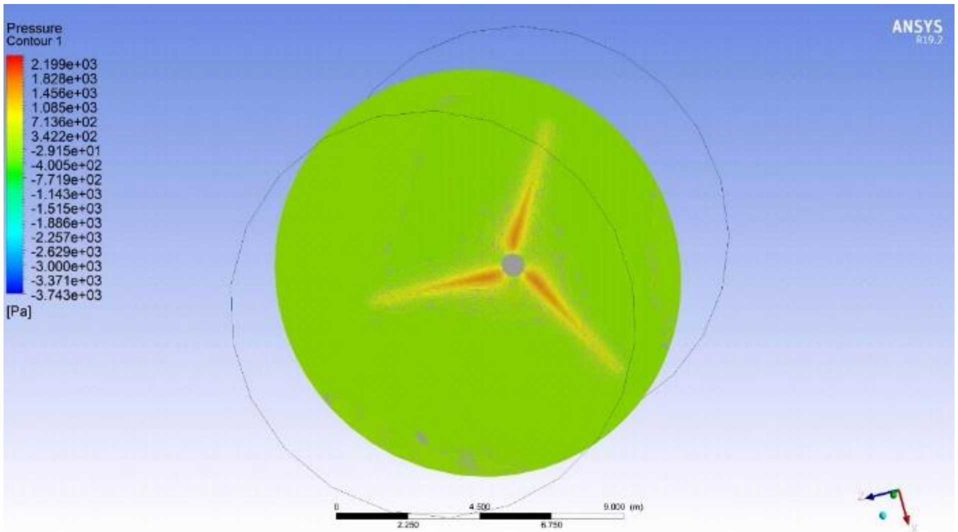
4.067e+01
3.559e+01
3.050e+01
2.542e+01
2.033e+01
1.525e+01
1.017e+01
5.084e+00
1.822e-09
[m s^-1]
ANSYS
R19.2
0
2.250
4.500
6.750
9.000 (m)

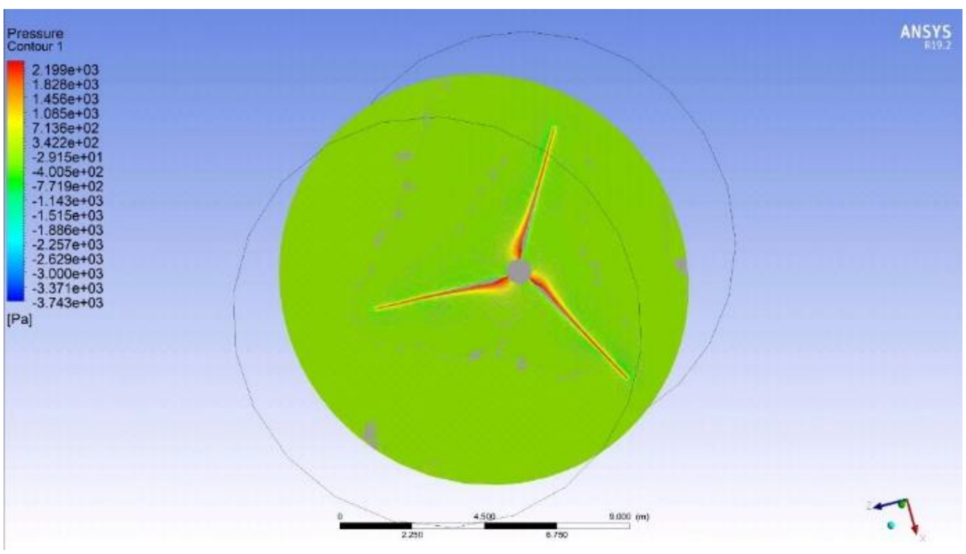

Velocity
Contour 1
7.316e+01
6.859e+01
6.401e+01
5.944e+01
5.487e+01
5.030e+01
4.572e+01
4.115e+01
3.658e+01
3.201e+01
2.743e+01
2.286e+01
1.829e+01
1.372e+01
9.145e+00
4.572e+00
1.080e-08
[m s^-1]
ANSYS
R19.2
0
2.250
4.500
6.750
9.000 (m)

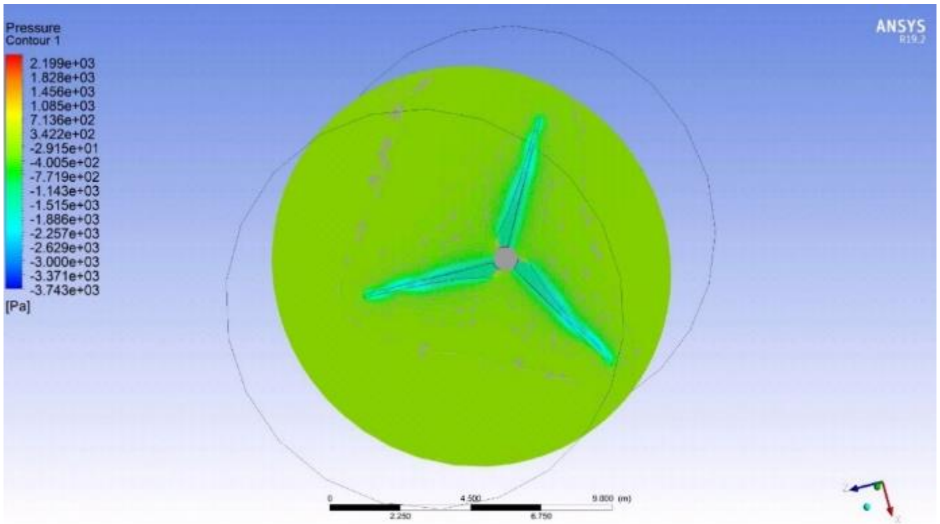

Velocity
Contour 1
6.461e+01
6.057e+01
5.653e+01
5.249e+01
4.846e+01
4.442e+01
4.038e+01
3.634e+01
3.230e+01
2.827e+01
2.423e+01
2.019e+01
1.615e+01
1.211e+01
8.076e+00
4.038e+00
1.074e-08
[m s^-1]
ANSYS
R19.2
0
2.250
4.500
6.750
9.000 (m)

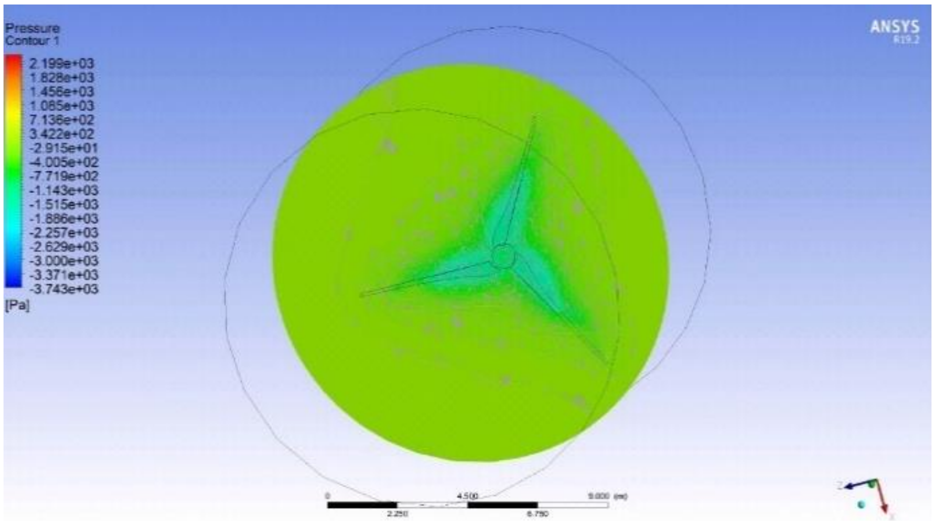
9.3) PRESSURE ANALYSIS OVER ROTOR BLADES:

Fig.5





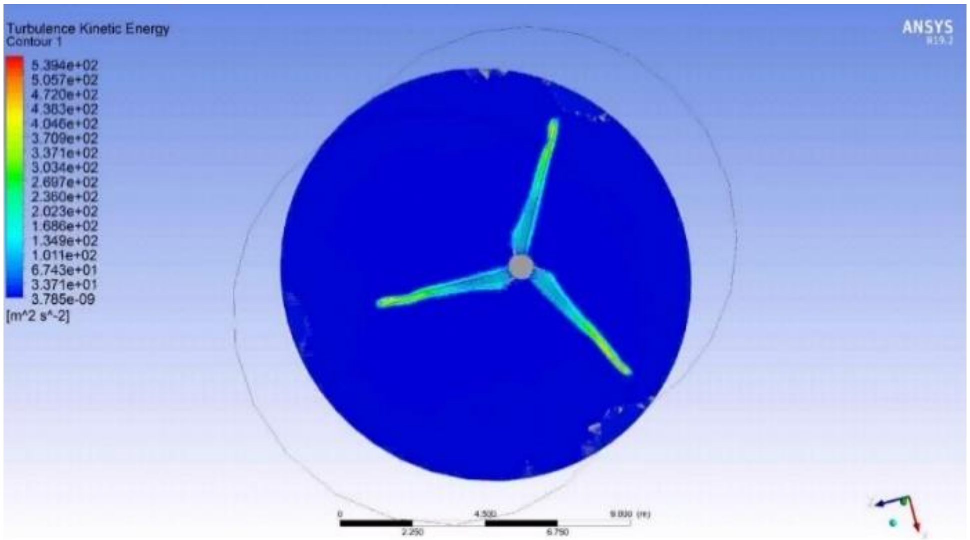


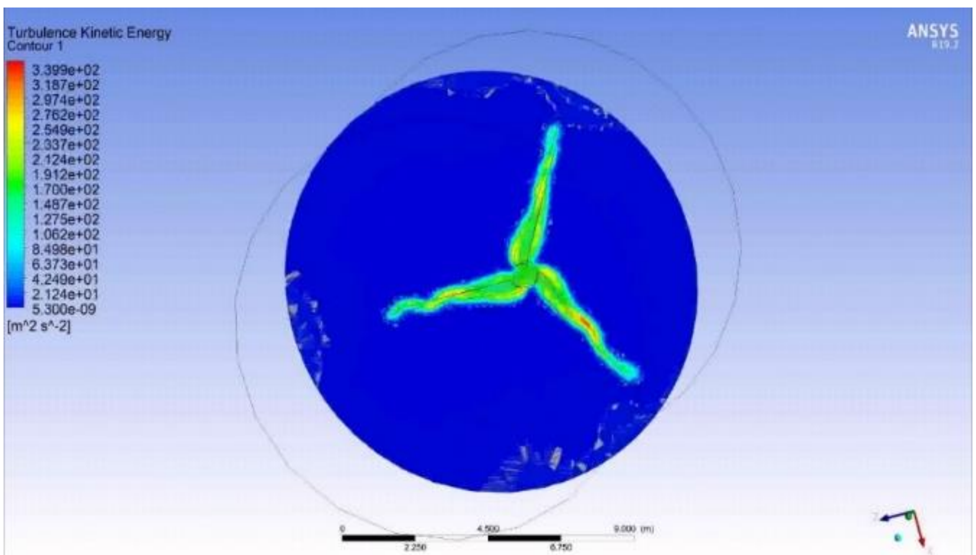


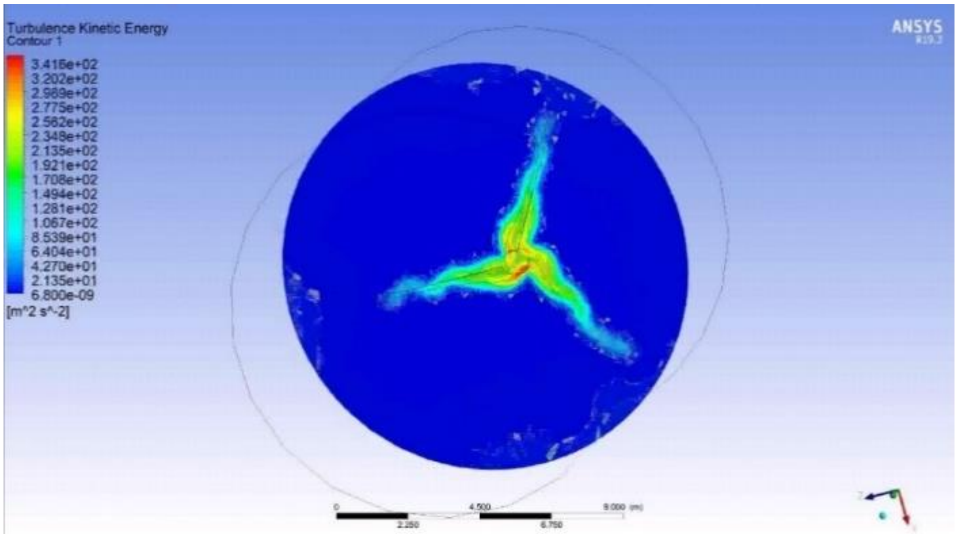
The pressure analysis is very important for the efficiency of the wind turbine. According to the scientist Albert Betz, a wind turbine cannot be more than 59% efficient. This is due to the pressure drop behind the turbine as shown in the above images. If the efficiency must be 100%, the pressure drop should be zero, which is impossible. This pressure drop keeps the wind flow going and keeps the rotor rotating. The results for the pressure analysis on the blades are shown above.

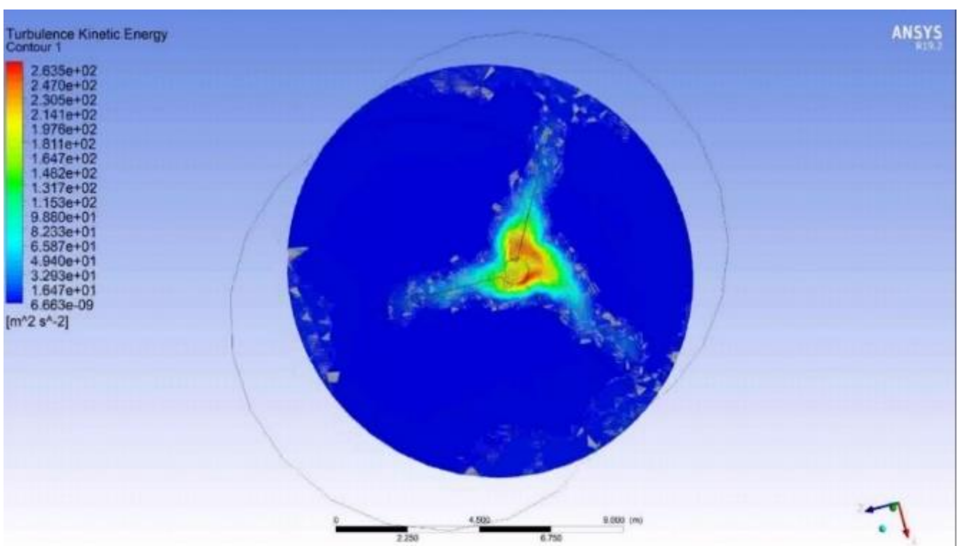
9.4) TURBULENCE CAUSED BY WIND OVER ROTOR BLADES:

Fig.6









9.41) WIND ENERGY CONERSION AND TURBULENCE

A wind energy conversion system extracts energy from the turbulent wind and while doing so creates extra turbulence.

2.1) The flow towards a wind turbine: The flow towards a wind turbine is essentially turbulent, with wind speed variations originating from production of turbulent kinetic energy due to surface roughness in combination with production or destruction of turbulent kinetic energy due to atmospheric stability.

2.2) The flow near a wind turbine: Upon approaching a wind turbine, the wind speed decreases and the turbulence increases in anticipation of the flow disturbing and energy extracting object. The flow near a wind turbine is modeled by using a rotor disk which contains the rotor blades.

2.3) The flow behind a wind turbine: The flow behind a wind turbine is sub-divided in three regions. In the near wake the flow is dominated by the velocity deficit due to the energy extraction and the vortices created at the tip of the rotor blades, resulting in a wind speed deficit and extra turbulence. In the intermediate wake the tip vortices gradually lose identity, and the undisturbed flow mixes with the core flow. As a result the wind speed deficit and the extra turbulence begin to decay. In the far wake equilibrium is assumed between the convective forces and the gradients of the turbulent momentum fluxes.

10) MATERIALS COMMONLY USED IN DESIGNING TURBINE BLADES

- Glass and carbon fibers.
- Aramid and basalt fibers.
- Hybrid composites
- Natural fibers

Table 4

S.N.	Material property	GFRP
1	Young Modulus(E)N/mm^2	$8.9*10^4$
2	Poisson’s ratio	0.1
3	Density kg/m^3	1850
4	Bulk modulus N/mm^2	$3.7083*10^4$

5	Shear modulus N/mm^2	$4.055*10^4$

In this analysis, we have used glass fiber Reinforced polymer for designing the wind turbine in Ug Nx software. The properties of this material are shown in table 4.

Conclusion

In the present project, a small HAWT of three blades was designed and computational analysis was done for the same. The turbine with all the components was designed by the Ug Nx software and the analysis was carried out by the Ansys workbench software. On the basis of results of analysis we came to know about the variation of stress with the cross sections of the blades, the amount of power that can be generated, variation of turbulence caused by the wind as it flows through the rotor blades. Wind turbines are a great source of energy. Their performance can be improved by further studies and modifications in their designs. Wind power only makes up a tiny percent of electricity that is produced. Unlike coal, wind turbines don't create greenhouse gases and are completely renewable source. By referring the articles, we got to know that if 2, 4, 6, or 8 blades are put on a wind turbine then, 8 blades will produce the most electricity because the more blades, the faster the wind turbine will turn, and more electricity will be produced. But when more blades are used in the turbine, the mass of the turbine increases, which in turn increases the manufacture cost and maintenance and decreases the efficiency of the turbine. Hence wind turbine manufacturers prefer a 3-blade design to get the maximum efficiency. Wind turbines should be designed by considering the cost, and transportation facility available. The objective of this project was to design a small scale wind turbine to generate a required amount of power and analyze its working principle, which is been achieved. The stress analysis shows that the displacement and stress act at different places in a rotor blade. The amount of power generated was calculated as 30.76kW using the Betz limit. The velocity, pressure and turbulence variation around the wind turbine rotor are also shown.We are looking forward to work on this topic for our major project.

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