KAUNAS UNIVERSITY OF TECHNOLOGY
FACULTY OF MECHANICAL ENGINEERING AND DESIGN

Manish Kumar Mothukur

DESIGN OF VERTICAL AXIS WIND TURBINE

Final Master's Degree Project

Supervisor
Assoc. Prof. Dr. Inga Skiedraitė

KAUNAS, 2015

KAUNAS UNIVERSITY OF TECHNOLOGY
FACULTY OF MECHANICAL ENGINEERING AND DESIGN
DEPARTMENT OF MANUFACTURING ENGINEERING

APPROVED BY
Head of Department
(signature) Assoc. Prof. Dr. Kazimieras Juzėnas
(date)

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Mechatronics (code 621H73001)

Supervisor
(signature) Assoc. Prof. Dr. Inga Skiedraitė
(date)

Reviewer
(signature) Assoc. Prof. Dr. D.Mazeika
(date)

Project made by
(signature) Manish Kumar Mothukur
(date)

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KAUNAS UNIVERSITY OF TECHNOLOGY

FACULTY OF MECHANICAL ENGINEERING AND DESIGN

(Faculty)

Manish Kumar Mothukur

(Student's name, surname)

Mechatronics (code 621H73001)

(Title and code of study programme)

"DESIGN OF VERTICAL AXIS WIND TURBINE "of final project

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Kaunas, 2015. 52 p.

SUMMARY

In this thesis an overview of the technology in vertical axis wind turbines (VAWT) is presented as preliminary investigation of certain characteristics of a new type of turbine design of this kind. After an introduction on the history of wind power, the analysis focuses to illustrating the main characteristics and the principle of operation of the different types of VAWT. After it describes the aerodynamic theory which is the basis of wind flow and provides an information about wind flow and control of blade depending on surrounding used for it.

A new concept of small scale vertical axis wind turbine design was developed with a modified aero foil GOE (Gottingen) 164 used in it, as blade is main element of the total wind turbine model design. The designing wind turbine's other supporting parts of blade like Top Part and Base part was done for the total wind turbine model design.

After it as the purpose of mechanical analysis, simulations tests like Von Mises stress, Strain Distribution & Displacement and air flow simulations were carried out for both blade element and total assembled wind turbine model design and results were extracted for technical observation.

As matter of innovation to achieve more precision in power transmission from wind turbine to generator with less power losses. An automated power transmission model structure was developed by using ORCAD software as platform for 8052 Microcontroller and verified with ISIS simulation. A program was developed using CODE KEIL software which make the total automation results a constant and standard output.

In total it is explained that the prescribed vertical wind turbine model design can be a good thought for an independent power production.

Keywords: Small scale vertical axis wind turbine, Gottingen aero foil, Automated power transmission model.

KAUNO TECHNOLOGIJOS UNIVERSITETAS
MECHANIKOS INŽINERIJOS IR DIZAINO FAKULTETAS

Tvirtinu:

Gamybos inžinerijos katedros vedėjas

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(parašas, data)

Kazimieras Juzėnas
(vardas, pavardė)

MAGISTRANTŪROS STUDIJŲ BAIGIAMOJO DARBO UŽDUOTIS
Studijų programa MECHATRONIKA

Magistrantūros studijų, kurias baigus įgyjamas magistro kvalifikacinis laipsnis, baigiamasis darbas yra mokslinio tiriamojo ar taikomojo pobūdžio darbas (projektas), kuriam atlikti ir apginti skiriama 30 kreditų. Šiuo darbu magistrantas turi parodyti, kad yra pagilinęs ir papildęs pagrindinėse studijose įgytas žinias, įgijęs pakankamai gebėjimų formuluoti ir spręsti aktualią problemą, turėdamas ribotą ir (arba) prieštaringą informaciją, savarankiškai atlikti mokslinius ar taikomuosius tyrimus ir tinkamai interpretuoti duomenis. Baigiamuoju darbu bei jo gynimu magistrantas turi parodyti savo kūrybingumą, gebėjimą taikyti fundamentines mokslo žinias, socialinės bei komercinės aplinkos, teisės aktų ir finansinių galimybių išmanymą, informacijos šaltinių paieškos ir kvalifikuotos jų analizės įgūdžius, skaičiuojamųjų metodų ir specializuotos programinės įrangos bei bendrosios paskirties informacinių technologijų naudojimo įgūdžius, taisyklingos kalbos vartosenos įgūdžius, gebėjimą tinkamai formuluoti išvadas.

1. Darbo tema

DESIGN OF VERTICAL AXIS WIND TURBINE

Patvirtinta dekano 2015 m.May mėn.11d. įsakymu Nr. ST17-F-11-2

2. Darbo tikslas

Aim of the project is to design a new model of a wind turbine by concentrating on modifying the blade design and other parts for a small scale vertical axis wind turbine.

3. Darbo struktūra

The working structure of project is to review types of the wind turbine. To design a small scale vertical axis wind turbine model and to simulate the model under mechanical analysis. To create an automated power transmission model for it.

4. Reikalavimai ir sąlygos

Requirements of project is to design a small scale vertical axis wind turbine model with automated power transmission model for independent power production.

5. Darbo pateikimo terminas 2015 m. June mėn. 1 d.

6. Ši užduotis yra neatskiriama baigiamojo darbo dalis

Išduota studentui _______________________

Užduotį gavau _______________________ _______________
(studento vardas, pavardė) (parašas, data)

Vadovas _______________________ _______________
(pareigos, vardas, pavardė) (parašas, data)

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1 Introduction

A wind turbine is a device that “converts kinetic energy from wind into electrical power”. This device is also known as “aero foil powered generator”. A wind turbine is used for electricity generation and it also referred as “wind charger” [1].

Vertical Axis Wind Turbines (VAWT) are considered as device which are adopting wind from all directions and doesn’t need of yaw mechanism, rudders or downwind coning. The electrical generators can be placed near to the ground and therefore very easy to use. Practical Horizontal Axis wind turbines (HAWT) have more efficiency than Vertical Axis Wind Turbines in converting the wind form of energy into electrical form. As this reason they have become most expensive popular accessories in commercial side of wind market. Therefore small scale vertical axis wind turbines are more suitable for urban usage, as they have low noise level and because of less risk involved in slow rotation rates.

- **Aim**

The aim of this project is to design new model of a wind turbine by concentrating on modifying the blade design for a small scale wind turbine. The project was motivated by continuous understanding of various renewable energy resource process and its power generation. During it an idea of the utilizing the maximum possible wind flow force to the blade of the turbine by creating a design with consideration of lift & drag force changes in it.

To achieve the aim of the project, the total work is distributed in few tasks, which reveled below.

The main tasks of the project includes are

1. Creating the model of a blade and the other supporting parts of blade. Then assemble the different model parts of the wind turbine.
2. Simulation of the wind turbine design model.
3. Creation of automatic power transmission model for wind turbine model.

2 Literature review of wind turbine types, its aerodynamics and automated manual transmissions

2.1 Types wind turbines

A basic Wind turbines is classified into two types based on axis of turbine spins [3].

- Horizontal axis wind turbines (HAWT)
- Vertical axis wind turbines (VAWT)

Wind turbines that works in horizontal axis are more common usage (like a wind mill), while vertical axis wind turbines are rarely used (Savonius and Darrieus are the common types in this group).

2.1.1 Horizontal axis wind turbines (HAWT)

Figure 2.1: Horizontal axis wind turbine (HAWT) [2]

Horizontal axis wind turbines, also knowns HAWT, are the common type that most of people think when they hear about a wind turbine. A HAWT has a same design like a windmill, it has blades that are similar to a propeller that spin on the horizontal axis [3].

Horizontal axis wind turbines has total equipment (the main rotor shaft and electrical generator) installed at the top of a tower and they have to be pointed towards the wind direction. Most of large wind turbines content a gearbox, which converts the rotor slow rotation into a faster rotation that is more suitable for working of electrical generator.

As tower creates turbulence from high speed wind, the turbine is normally pointed on upwind of the tower. Blades of Wind turbine are made stiff to prevent deformation of blades due to pushing into the tower caused by high winds. Additionally, the blades are arranged in a calculated distance in front part of the tower and in some conditions tilted up a small amount [3].

Apart the problem of turbulence, downwind machines has been constructed. As they don't need an extra kind of mechanism for keeping them in contact with the wind. Additionally, in high winds the blades are allowed to bend which reduces their swept area and thus their wind resistance. As turbulence results fatigue failures, and reliability is so important, most of the HAWTs are upwind machines.

HAWT advantages [3]

- Huge tower base allows chance of getting stronger wind in sites with wind shear. In some wind shear sites, every 10 meters up the wind speed can increase by 20% and 34% of power output.
- High efficiency, as the blades always works perpendicularly to the wind, receiving power from whole rotation. Were as in all vertical axis wind turbines and most of aerodynamic based wind turbine designs involves different types of reciprocating actions, particular airfoil surfaces to backtrack against the wind for part of the cycle. Backtracking against the wind leads to inherently lower efficiency.

HAWT disadvantages [3]

- Huge tower construction is needed to withstand and support the heavy blades, gearbox, and generator.
- Their height makes them obtrusively visible across large areas, disrupting the appearance of the landscape and sometimes creating local opposition.
- Downwind variants suffer from fatigue and structural failure caused by turbulence when a blade passes through the tower's wind shadow (for this reason, the majority of HAWTs use an upwind design, with the rotor facing the wind in front of the tower).
- HAWT requires yaw control mechanism to turn the blades toward the wind.

2.1.2 Vertical axis wind turbines (VAWT)

Figure 2.2: Vertical axis wind turbines (VAWT) [4]

Vertical axis wind turbine also knowns VAWT, a rotor shaft will be arranged vertically. For the arrangement, the wind turbine has an advantage where the wind direction is highly variable and don't need to be pointed into the wind [5].

Due to the lower wind speed at the lower attitude like ground level and just above the ground level ,the less wind energy is available for the given size turbine and near the ground level the issues of vibration may occur due to this there will be damage in bearing and gears like wear and tear and noise too.

When wind turbine is mounted on the rooftop the wind flow will be more by this we accept maximum wind energy and less turbulence. The main drawback of this kind of wind turbine generally drags when rotating into the wind [5].

2.1.2.1 VAWT subtypes

2.1.2.1.1 Darrieus wind turbine

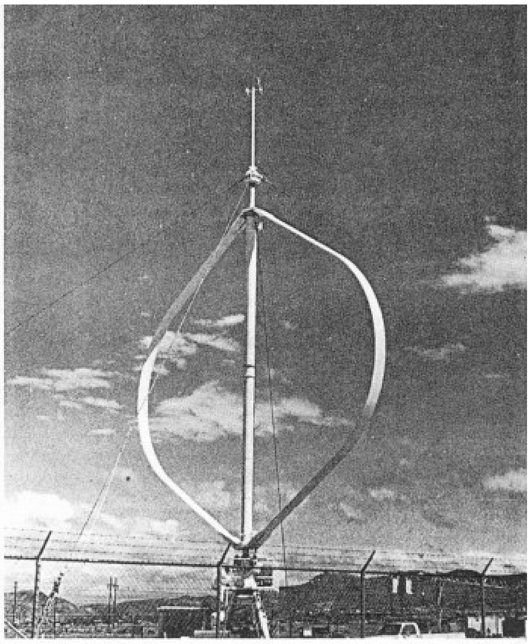


Figure 2.3: Sandia laboratories 17-m darrieus, rated at 60 kw in a 12.5-m/s wind [6].

Theses wind look like a giant egg beater so they are usually known as ‘Egg Beater Turbine’ [5]. These are having good efficiency but it produces large cyclic stress on the tower and torque ripple which results in poor reliability.

These turbines generally need extra power source to start up the turbine because the starting torque will be very low. The solidity is measured by blade area through over rotor area. The torque ripple can be reduced by placing three or more blades resulting in high solidity.

2.1.2.1.2 Savonius wind turbine

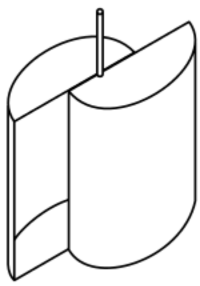


Figure 2.4: Savonius wind turbine [7]

These turbines are commonly used high reliability such has ventilation and anemometers. These turbines are excellent in turbulent wind and self-starting areas [5].

VAWT advantages [5]

- A VAWT can be located nearer the ground, making it easier to maintain the moving parts.
- VAWTs have lower wind startup speeds than the typical the HAWTs.
- VAWTs may be built at locations where taller structures are prohibited.

VAWT disadvantages [5]

- These are having less efficiency when compare to HAWT, because of drag have their blade rotates.
- These are not commonly deployed mainly to the serious advantages.

2.2 Wind turbines working principle and its considerations

Wind turbine converts kinetic energy of the wind to the torque caused by turbine which drives the electrical generator. Wind will be having particular mass, by means of different gearing system; the kinetic energy will be converted in to mechanical energy [8].

There are two different types of blade designs, lift type and drag type:

- **Lift type:**

  This is a common type of modern horizontal axis wind turbine blade will be seen in big wind farms. This resembles to aero plane wing. The wind travel along the blade and leads to creating a lower air pressure on tailing edge. The pressure pulls and pushes the blade around a turbine [8].

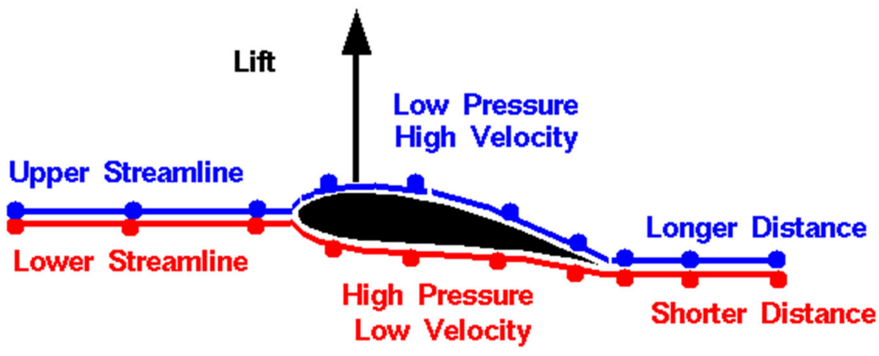


Figure 2.5: Lift force illustration [9]

- **Drag type:**

  This type of turbine used the force of the wind to move the blade. A savonius is a perfect example of the design, this is resisted by blade and winds force on it moves it around. This design normally creates a slower rotation speed with high torque than a lift [8].

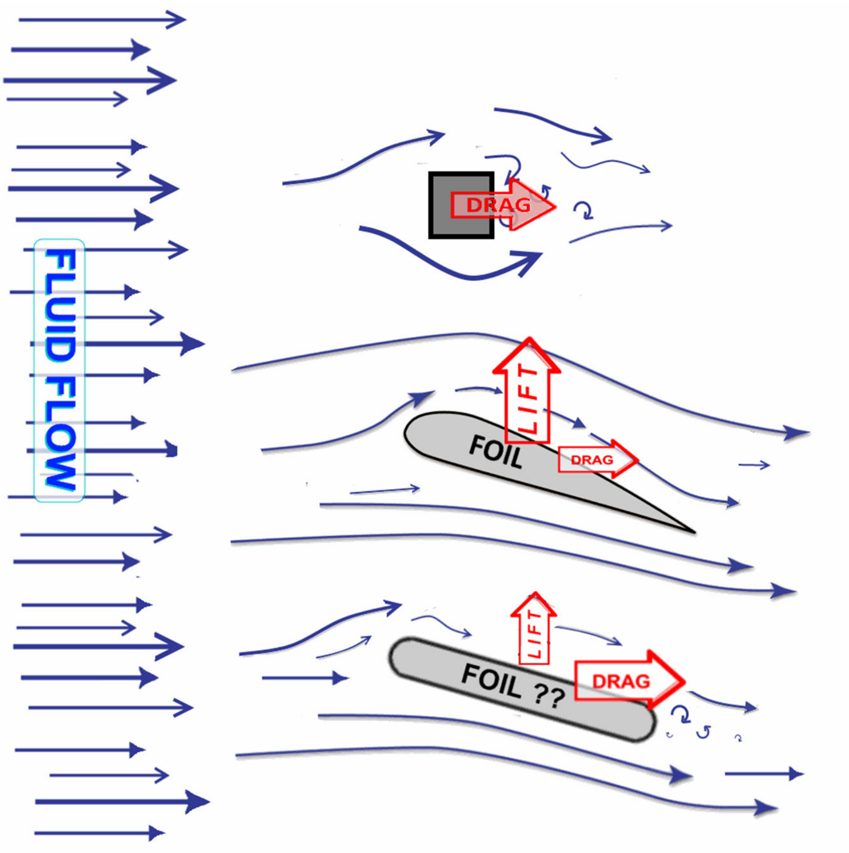


Figure 2.6: Drag force illustration [10]

2.3 Theory of wind turbine aerodynamics

From an aerodynamic point of study, there are many types of common aspects of Vertical axis Wind Turbines (VAWT) which differ them Horizontal Axis Wind Turbines (HAWT).

The VAWT blades rotates on right angle rotational surface with respective to the wind direction. The aerodynamic angle of attack of the blades varies constantly during the rotation.

Apart from it, the particular blade turns in 180° to 360° in the range of rotational angle with respective to downwind side of the other blade as result the wind speed is reduced in this area by the energy extracted from the upwind blades. Hence, power generation is much less in the downwind rotation of sector [11].

The concept of the flow velocities and aerodynamic forces explains that, lift forces of blade produced a torque on other hand drag forces of blade produced much is in this way which is caused by the. The breaking torque of the in much lower from comparison.

The alternation of the torque with the revolution can be balanced with three rotor blades, to such an extent that the alternating variation becomes an increasing and decreasing torque which is positive throughout. However, torque can only develop in a vertical axis rotor if there is circumferential speed: the vertical axis rotor is usually not self-starting.

In order to study the rotor aerodynamics and to get its power generation information, it is needed to start by considering that a wind turbine runs converting the kinetic energy of a wind flow for electricity generation.

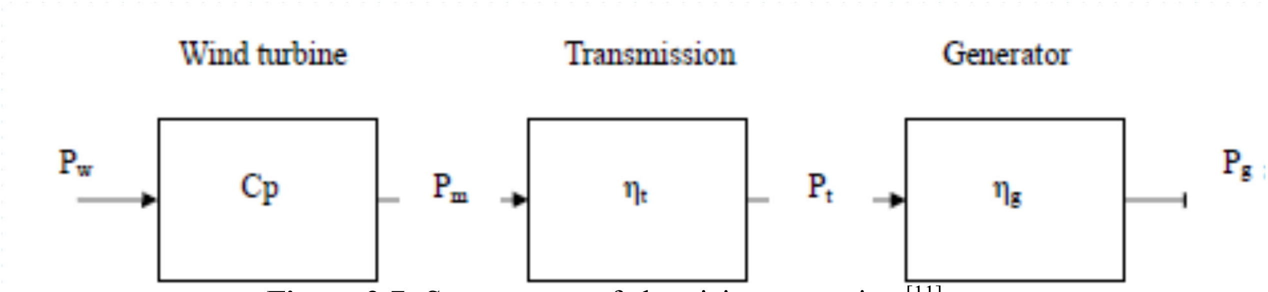


Figure 2.7: Step process of electricity generation [11]

From the above figure wind flow (wind power P_w) the turbine gets the force to rotate the blades. The force produced by this rotations is transferred to the main shaft (or to a gearbox, if it is present) as torque (P_m) and from there the torque is used for electrical generator, which provide the electricity to the source (P_g).

2.3.1 WAsP

Wind Atlas Analysis and Application Program (WAsP) is a computer program that utilizes user inputted wind data to predict wind climates, map wind resources, and calculate power productions from wind turbines and wind farms. The program was developed by DTU Wind Energy in Denmark, and is now the worldwide industry standard software for wind resource assessment and siting of wind turbines. While it is usually used in rural areas, it does include complex terrain flow, roughness, and sheltering obstacles model which makes it adaptable for urban areas [12].

2.3.2 Wind gradient

For the calculation of wind speed at the height of the hub, the wind speed has to vary with height due to the friction against the ground which shows the wind, such phenomenon is known as wind gradient or wind profile.

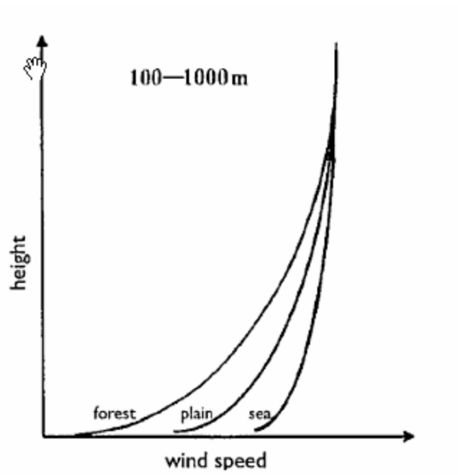


Figure 2.8: Wind speed profile for various locations [13]

Table 2.1: Roughness classes [13]

Roughness Class	Type of Terrain	A
0	Open Water	0.1
1	Open Plain	0.15
2	Countryside with farms	0.2
3	Villages and low forest	0.3

2.3.3 Control of the blade in wind turbine

Generally a wind turbine is designed to be operated in a range of wind speed from 4 m/s to 25 m/s, [14] as a result the generated power increases due to the rated power, the control system due to the rated power, the control system is generally essential to avoid high rotational speed caused by high rotational speed which creates strong stress and damage the tower. As result active control and passive control of wind turbine is changed by angle attack and pitch angle.

The passive control of a fixed wind turbine has a fixed rotational speed, which results in having the advantage when the wind speed increases, it conclude in defending the value of the lift force and coefficient of power c_p.

Hence, the value of α increases hence, the lift force decreases. The active control of variable rotational speed of wind turbine consist electrical equipment for the rotation of blade around their own axis to reach the feather of blades or the stall.

- **Pitch control toward the stall:**

By rotating the blade, the angle of attack is increased and the β pitch angle is reduced. This situation brings to the stall of the blade, with a strong reduction of the component Fc, the one that make the turbine rotate. This is a quick way to control the rotational speed, but creates stress on the tower (Fs is still high) [14].

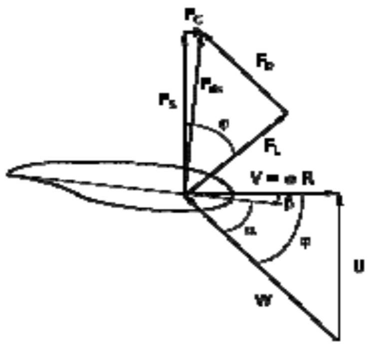


Figure 2.9: Pitch control toward the stall [14]

- **Pitch control toward the feather:**

By increasing the angle β, a reduction of the rotational speed can be got, due to the reduction of the component Fc. This is a slower way of control the blades, compared with the pitch control toward the stall, but it reduces much more the stress on the tower, by decreasing also the value of F_s [14].

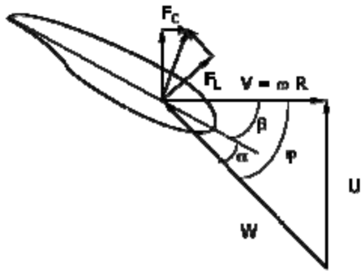


Figure 2.10: Pitch control toward the feather [14]

The resultant force F_r is of the vector sum of F_L and F_D can be divided in two component:

- F_c: on the direction of the rotation of the wind turbine; it's the force that make the turbine rotate;
- F_s: releases its energy on the structure of the tower, flexing it.

2.4 Automated manual transmissions

The Automated Manual Transmissions (AMT) [15] is a term used in intermediate technological solution between the manual transmissions. In automated manual transmissions generally uses a + or – button unlike manual transmissions by using gears and clutches. The AMT automatically dis engages the clutch by changing gear and engages clutch automatically while the modulation of throttle, the driver has an option of an automated mode. It is advantageous solution on manual transmissions systems with automatic control technology for an easier performance and use on operation.

Degrees of automation are of two types they are:

1. Full automation.
2. Semi automation.

AMT has a greater advantage over manual transmissions as human mechanical power required where human participation is very minimal.

Generally pneumatics forms an attractive medium for low cost automation it can also be achieved through hydraulics, computers, and robotics. Pneumatic systems also have an advantage of being very economic and simpler. Automation also plays an important role in mass production [15].

Advantages involved [15]

- Gears can be changed automatically without a human mechanical movement of clutch.
- No modification in engine and gear.
- Very few psychological and physical stresses.
- Very comfortable when compared to manual transmissions.

3 Methodology used for designing the wind turbine

3.1 Design approach for creating a new model wind turbine

The below algorithm is the explanation of the design approach included in creating a blade for a new model wind turbine.

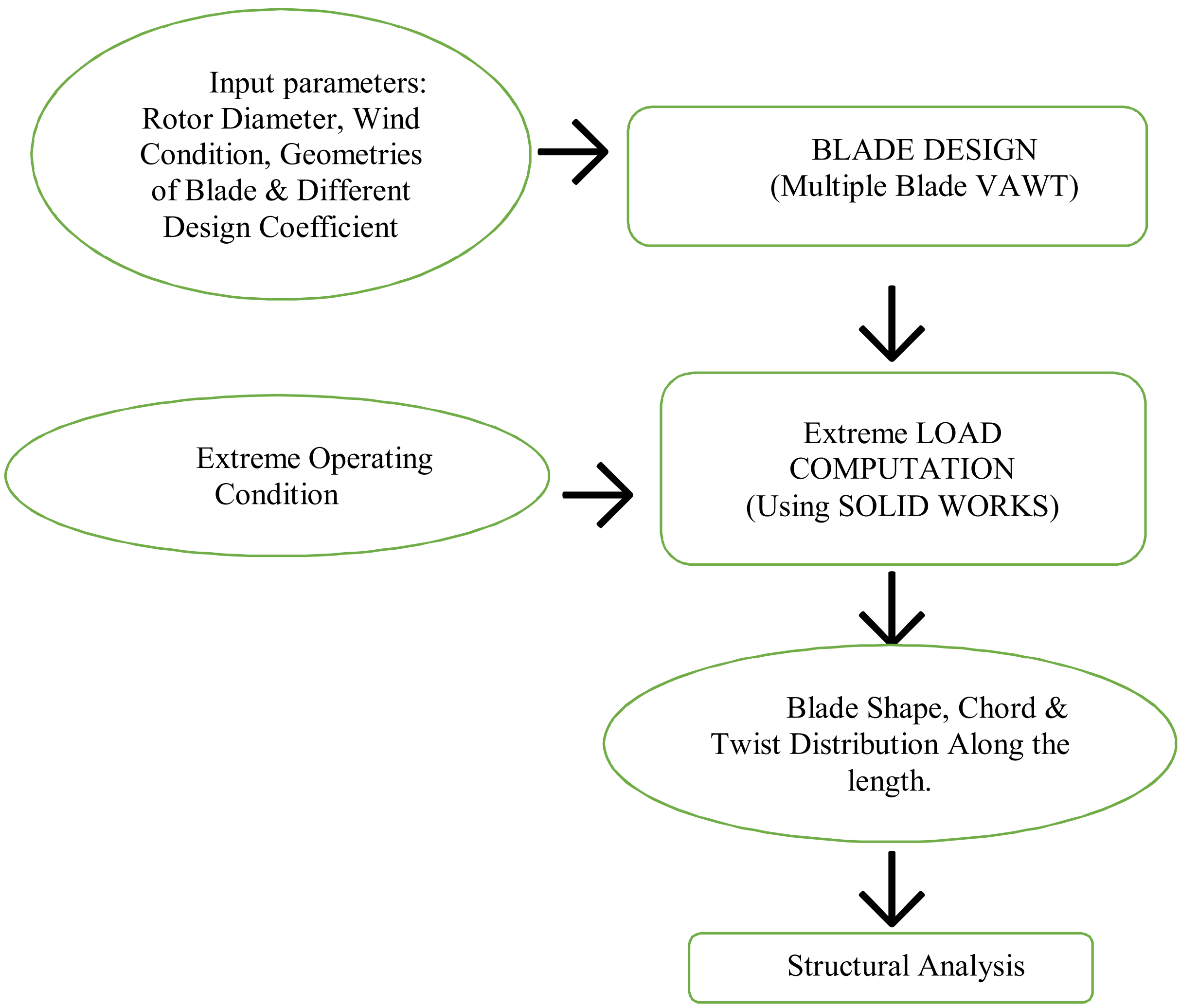


Figure 3.1: Design approach algorithm

Initially an aero foil (GOE 164) is selected for Vertical Axis Wind Turbine (VAWT) operation which satisfies the required Input parameters: Rotor Diameter, Wind Condition, and Geometries of Blade & Different Design Coefficient.

Later a blade design is prepared by using the selected Aero foil plot co-ordinates generated by required geometry and undergoes many simulation processes by using Extreme Operating Condition like pressure, force and contact point.

3.1.1 Design process

The design of the presented wind turbine blade is adopted from a GOE 164 airfoil. [16] [Appendix 2] all the parameters were considered according to the design standards of a vertical axis wind turbine (VAWT). The following steps were used as parameters for designing the blade.

- **Step1:** select an airfoil which satisfy the need of model and customize the diameters according to the required geometry outline dimensions using aero foil generator [16].
- **Step2:** extract the co-ordinates from the step 1 results and produce the exact profile in solid work design software.
- **Step3:** from extracted profile the total blade design is constructed according to requirement of the concept and create others additional parts like base part and top part, which have satisfied particular concept requirements of their own standard in order to make complete ideal wind turbine design.
- **Step4:** after the completion of wind turbine parts design, assemble them and execute the analysis in order get results for theoretical observation.

The purpose of analysis is to show the properties of the design regarding natural parameters without creating prototype, so as result of various sub-assembly parts of the wind turbine were modelled and the final assembly was assembled in SOLIDWORKS.

3.2 Material specifications

The used material for device is **Aluminium alloy 6061**

Aluminium alloy 6061 is a medium to high strength heat-treatable alloy with strength higher than 6005A. It has very good corrosion resistance and weldability although reduced strength in the weld zone. It has medium fatigue strength. It has good cold formability in the temper T4, but only limited formability in T6 temper. Not suitable for very complex cross sections [17].

Chemical composition

Table 3.1: Chemical composition of aluminium alloy 6061 [17]

Chemical Element	% Present
Manganese (Mn)	0.0 - 0.15
Iron (Fe)	0.0 - 0.70
Magnesium (Mg)	0.80 - 1.20
Silicon (Si)	0.40 - 0.80
Copper (Cu)	0.15 - 0.40
Zinc (Zn)	0.0 - 0.25
Titanium (Ti)	0.0 - 0.15
Chromium (Cr)	0.04 - 0.35
Aluminium (Al)	Balance

Properties

Table 3.2: Physical properties of aluminium alloy 6061 [17]

Physical Property	Value
Density	2.70 g/cm³
Melting Point	650 °C
Thermal Expansion	23.4 x10^-6 /K
Modulus of Elasticity	70 GPa
Thermal Conductivity	166 W/m.K
Electrical Resistivity	0.040 x10^-6 Ω .m

Table 3.3: Mechanical properties of aluminium alloy 6061 [17]

Mechanical Property	Value
Proof Stress	270 MPa
Tensile Strength	310 MPa
Elongation A50 mm	12 %
Shear Strength	190 MPa
Hardness Vickers	100 HV

Temper Types [17]

The most common temper for 6061 aluminium is:

- T6 - Solution heat treated and artificially aged

Supplied Forms [17]

- Alloy 6061 is typically supplied as Extrusions

Weldability [17]

- Weldability – In Gas type: Good, In Arc type: Very Good, In Resistance type: Good
- Brazability: Good
- Solderability: Good

3.3 Automatic power transmissions model parts utilization in wind turbine

- **CPU**

The CPU central processing unit is generally used in executing programming instructions. It consists of an external crystal which provides timing for clocking the CPU types of instructors including (addition, subtraction) logic (AND, OR and NOT) by data transfer and program branching operations [18].

- **ROM**

Read Only Memory is programmed into a chip in the manufacturing process. The 8052 – BASIC contains a BASIC-52 interpreter program with 8052 executes on boot up which is the only difference between an 8052 BASIC and 52-BASIC [18].

- **RAM**

Random Access Memory is the place used for storage of programs for temporary use. The CPU can either read or write on RAM. The 8052 generally consist 256 bytes of RAM. A BASIC-52 uses as much as RAM for its operations by leaving very few bytes available to users to work [18].

- **I/O Ports**

An input/output (I/O) port generally enables to read and write onto an external memory and other components. The 8052- has four 8 bit I/O ports .These port Bits are optional which have alternate functions for accessing externally memory, using timers and counters for handling. Serial commands and external interruptions BASIC-52 assigns alternate functions for port bits, these functions are generally required BASIC-52 [18].

- **The serial port**

These 8052's ports generally take care of serial communications; the serial port transfers bytes of data being sent into serial data. Including start and stop bits by writing the data in a timer sequence to SER out. In the receive side, the serial port accepts serial data at SER in setting a flag by indicating that a byte has been received by BASIC-52 using the serial port for communicating with a host computer [18].

- **External interrupts**

These interrupts generally detect logical levels or transistors that interrupt the CPU .INT 0 and INT 1 Are external interrupt inputs BASIC 52 uses INTO for its optional Direct Memory Access DMA) function [18].

- **Power Supply Connections**

The chip has two pins for connecting to a +5-volt DC power supply (VCC) and ground (VSS). That finishes our tour of the 8052-BASIC chip. We're now ready to put together a working system [18].

- **Pneumatic Cylinders**

The cylinders are mechanical devices which generally used the compressed gas power to produce a reciprocating linear motion (these ae also known as pneumatic cylinders).

Pneumatic cylinder consists of two openings one on the top and another below. The compressed air passes through the value therefore piston inside the cylinders gets energized and the piston head gets out ejected. The pressure used in this pneumatic cylinder must be 2 bar, but due to the cylinder pressure in can be about 4-5 bar [18].

Generally we prefer pneumatic cylinder than fluid cylinder as pneumatic cylinder has no fluid drippings and it will not affect he surroundings. As with the categorization pneumatic cylinders can be divided into 2 types

- Single acting cylinder (SAC)
- Double acting cylinder(DAC)

Single-acting cylinders:

Single Acting Cylinders (SAC) Uses the imparted pressure by compressed air to create driving force only in one direction (usually out), and a spring to return to home position. Often, this type of cylinder has limited extension due to the space the compressed spring takes of another side of SAC's is the port which is forced by the cylinder is lost as it is push against the spring [18].

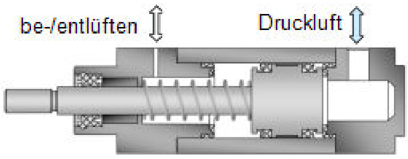


Figure 3-2: Single acting cylinder [19]

Double-acting cylinders

Double Acting Cylinders (DAC) uses the force of an air flow for an outstroke. The piston red is more vulnerable for the design and it is not limited. Thus, the piston rod is more vulnerable for buckling and bending [18].

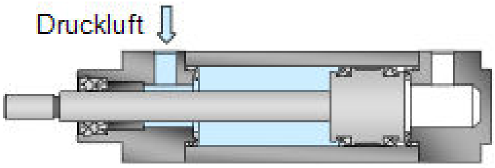


Figure 3-3: Double-acting cylinders [20]

4 Practical implementation of wind turbine model, power transmissions and there results

4.1 Creating of the wind turbine model

This is the first step in the realization of this thesis. The windmill has to be build using CAD program Solid Works 2013 SP5.0, trying to follow a determinate distribution of its parts and Sketches. In order to execute Von Mises stress, Strain Distribution & Displacement analysis for theatrical observation.

One must be very careful while designing the wind turbine. Of course, some errors can be committed, but all the work that will be done after this task will depend on the way the wind turbine design is adopted. This means that all the mistakes should be identified and repaired, if some parts of them are missing which means that the concern information is may not require to the work of the project.

4.2 Designing of the wind turbine parts

When the wind turbine is built, it is done as an assembly of different parts and sketches. To achieve a good level of result, it is strongly recommended to divide the product geometry into different subassemblies.

In these subassemblies, it is important to differentiate between the components and the structural parts of the windmill, as depending on this fact the different specific concern parts will not belong to the same subassembly.

It is important to know the difference between components and structural parts, to know in which subassembly they have to be assigned. Components normally are parts with static geometries, where they are replaced rather frequently according to problem demand.

The units used in designing and simulating the model of wind turbine is shown down in following table.

Table 4.1: Units used in wind turbine design and simulation

Unit system:	**SI (MKS)**
Length/Displacement	Mm
Angular velocity	Rad/sec
Pressure/Stress	N/m^2

4.2.1 Top part of wind turbine model

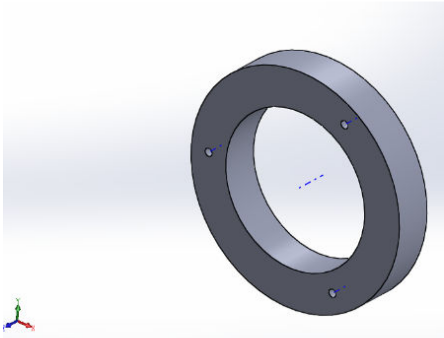


Figure 4.1: 3D view of Top part

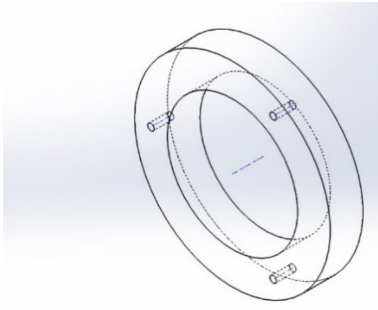


Figure 4.2: 3D Line View of Top part

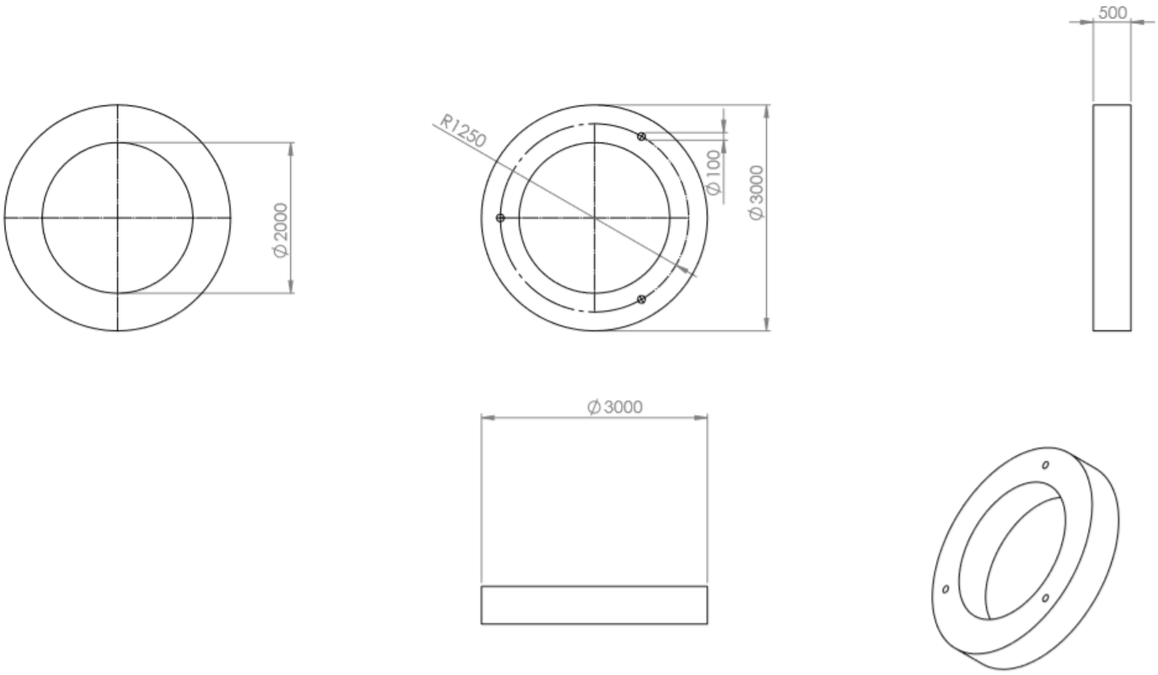
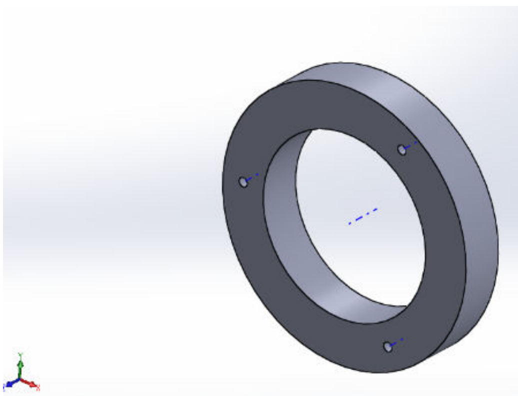


Figure 4.3: 2D sheet View of Top part

Table 4.2: 3D view and volumetric properties of Top part

Part Name of wind turbine: Top part	**Volumetric Properties**
	Mass:5282.35 kg
	Volume:1.95643 m^3
	Density:2700 kg/m^3
	Weight:51767.1 N

The top part is designed in such a way, which does not require a high level of accuracy in design, so most of its elements can be neglected but it should be able to fix with blade part which shown further in the report for this reason there is an extra feature of 3 holes with diameter 100mm and width of 200mm. its final shape can be as one showed in the Figures 4.1, 4.2, & 4.3 and its volumetric properties are also represented in Table 4.2.

4.2.2 Base part of wind turbine model

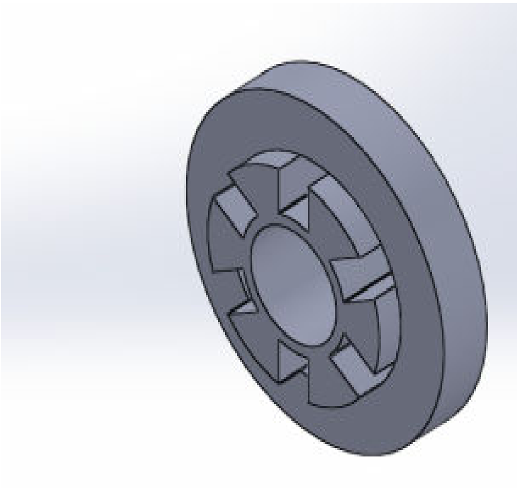


Figure 4.4: 3D-View of base part

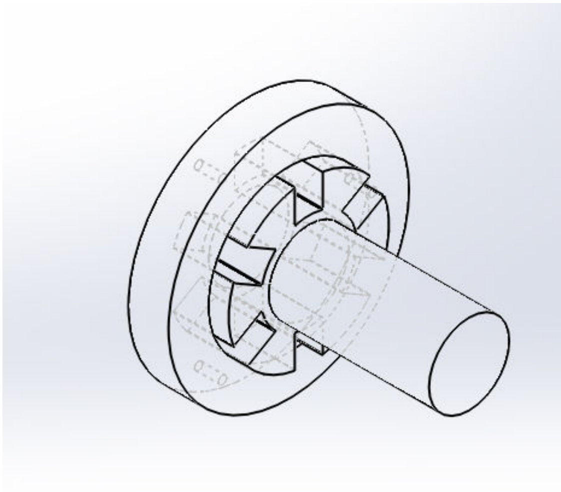


Figure 4.5: 3D-Line View of base part

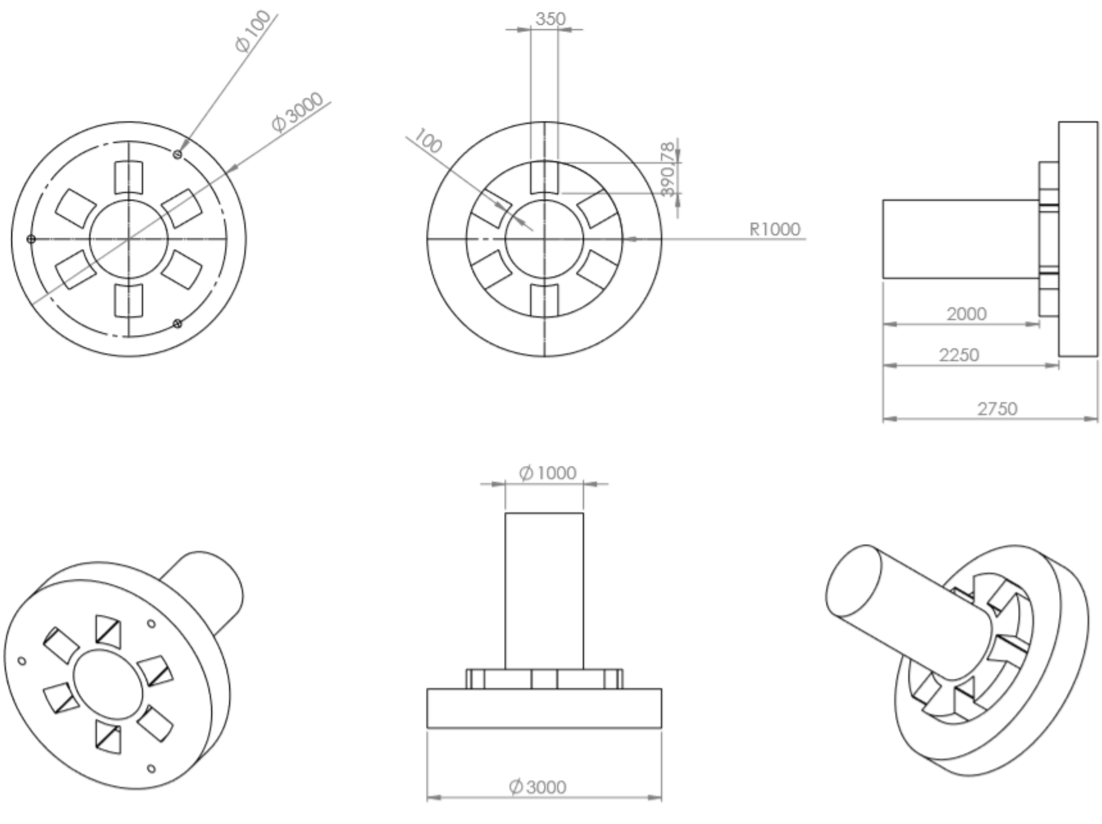
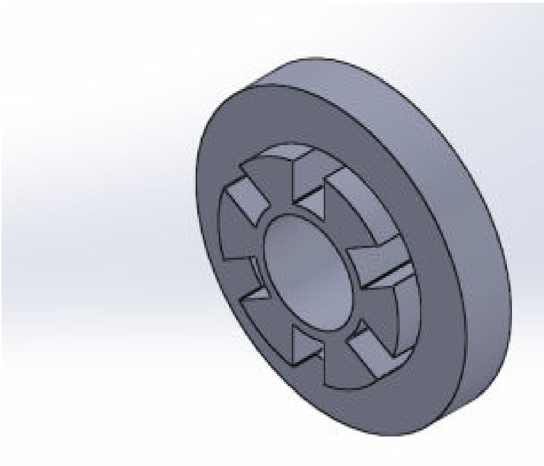


Figure 4.6: 2D sheet View of base part

Table 4.3: 3D view and volumetric properties of Base part

Part Name of wind turbine: Base part	**Volumetric Properties**
	Mass:14170.7 kg
	Volume:5.24841 m^3
	Density:2700 kg/m^3
	Weight:138873 N

The base part design is similar top part design which does not require a high level of accuracy except weight distribution at center, so most of its elements can be neglected by reducing the weight at center. This part also has 3 holes with diameter of 100mm and width of 200mm for fixing with other side of blade part design and its final shape can be as one showed in the Figures 4.4, 4.5 and 4.6. Its volumetric properties are represented in Table 4.3.

4.2.3 Blade part of wind turbine model

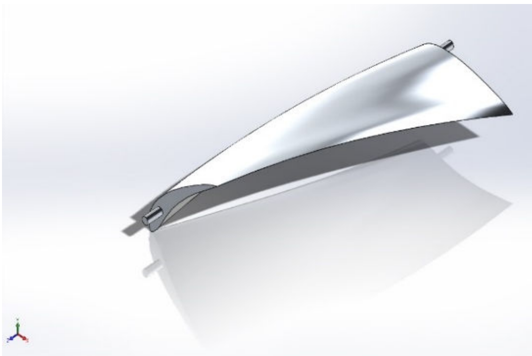


Figure 4.7: 3D-View of blade part

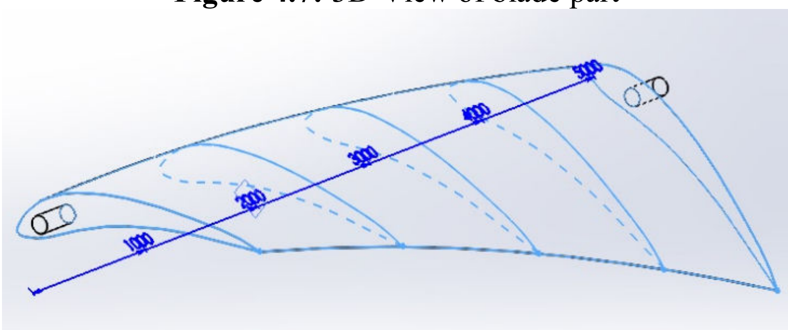


Figure 4.8: 3D Line view of blade part

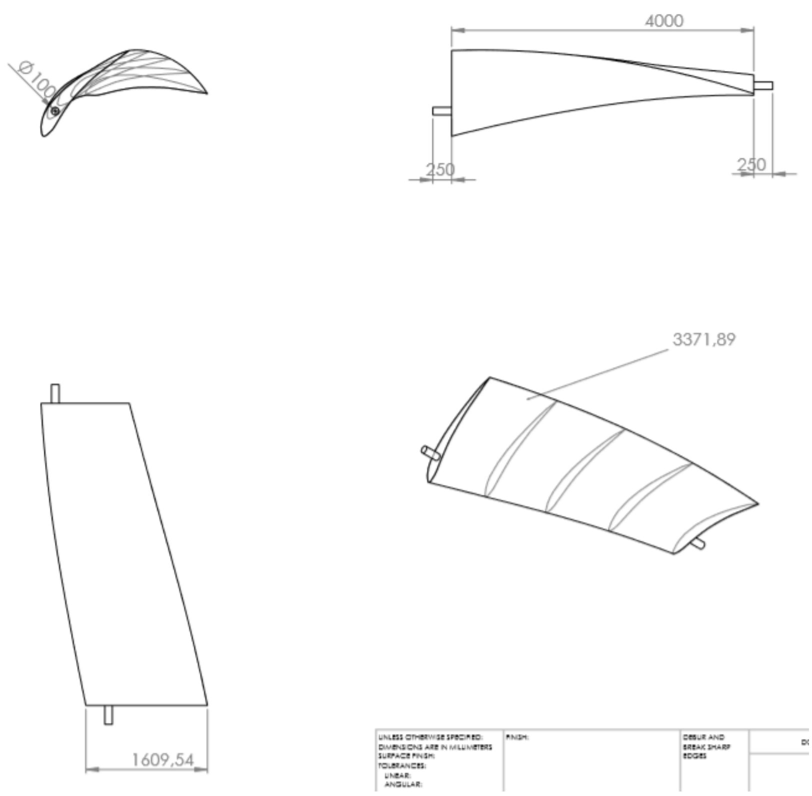
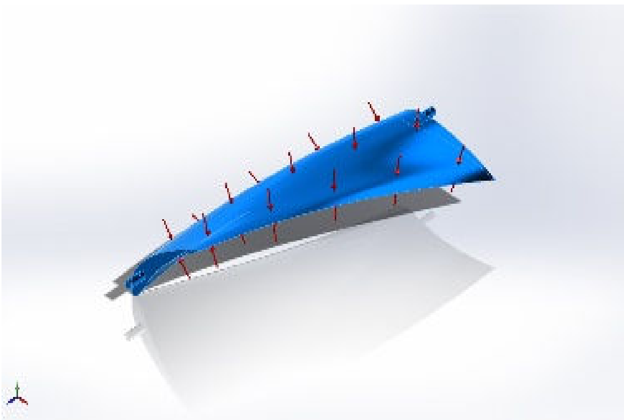


Figure 4.9: 2D sheet View of blade part

Table4.4: 3D view and volumetric properties of blade part

Part Name of wind turbine: Blade Part (GOE 164)	**Volumetric Properties**
	Mass:2274.74 kg
	Volume:0.842498 m^3
	Density:2700 kg/m^3
	Weight:22292.5 N

The blade used in the mind will is length of 4 meters and width of 1.8 meters. It has to two small cylinder shafts with diameter of 100mm and length of 250mm for easy which helps to fix with base part and top part designs in assembly. The aero foil used in blade is GOE 164 which is generated for modified profile shown in detail below. The area of airfoil is 3378 mm and its final shape are showed in the Figures 4.7, 4.8 and 4.9. Its Volumetric Properties can be as one showed in the Table 4.4.

GOE (Gottingen) 164

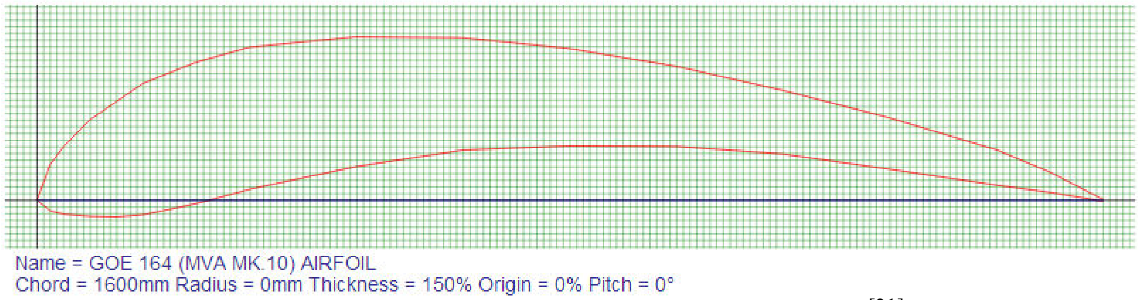


Figure 4.10: Modified GOE 164 Aero foil [21]

This blade profile (Figure 4.10) is used with five different various profiles generator by changing the pitch angle from 0°-45°staing from front to center of the airfoil. In order to customize profile in Solid Works the requirement of co-ordinates were mandatory [21].

4.2.4 Total assembly of wind turbine model

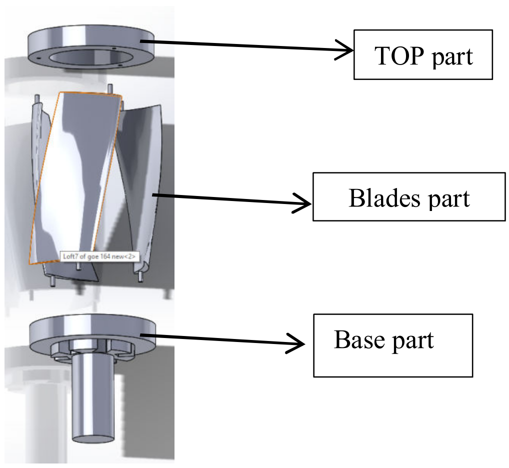


Figure 4.11: Parts of total assembly

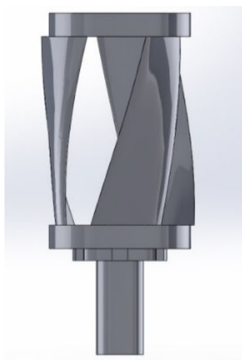


Figure4.12: Total assembly of wind turbine

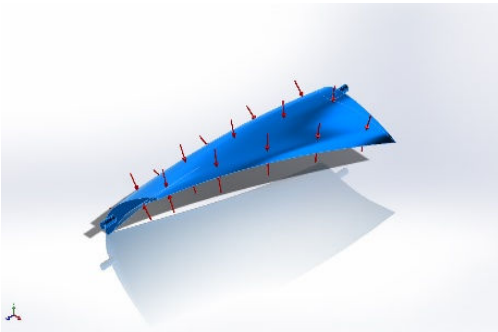
The above Figure 4.11 & 4.12 explains the names and position of parts used in total assembly of wind turbine model and its final design obtained with dimensions of length 7.25 meters (7250 mm) and width of 3.4 meters (3400 mm).

4.3 Simulations of blade part and total assembled wind turbine model

4.3.1 Simulation of blade part in wind turbine model

In the previous figures of total assembly the main component is blade, which is analyzed and shown in aspects of stress, displacement and strain concepts they are

Table 4.5: Properties of blade in simulation

Model Reference	Properties	
	**Name:**	6061 Alloy
	Model type:	Linear Elastic Isotropic
	Default failure criterion:	Max von Mises Stress
	Yield strength:	5.51485e+007 N/m^2
	Tensile strength:	1.24084e+008 N/m^2
	Elastic modulus:	6.9e+010 N/m^2
	Poisson's ratio:	0.33
	Mass density:	2700 kg/m^3
	Shear modulus:	2.6e+010 N/m^2
	Thermal expansion coefficient:	2.4e-005 /Kelvin

Meshing Result of blade part in wind turbine model

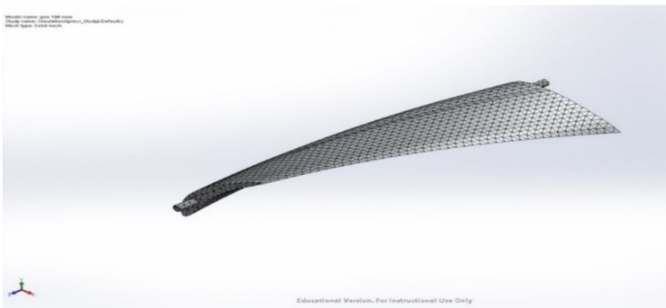


Figure 4.13: Meshing of blade part in wind turbine model

The above figure 4.13 shows the solid type meshing result of blade using aluminum alloys 6061 which results in the edge and point for simulation of the blade.

Stress Result of blade part in wind turbine model

Name	Type	Min	Max
Stress	VON: von Mises Stress	0.0313722 N/m^2	758.4 N/m^2

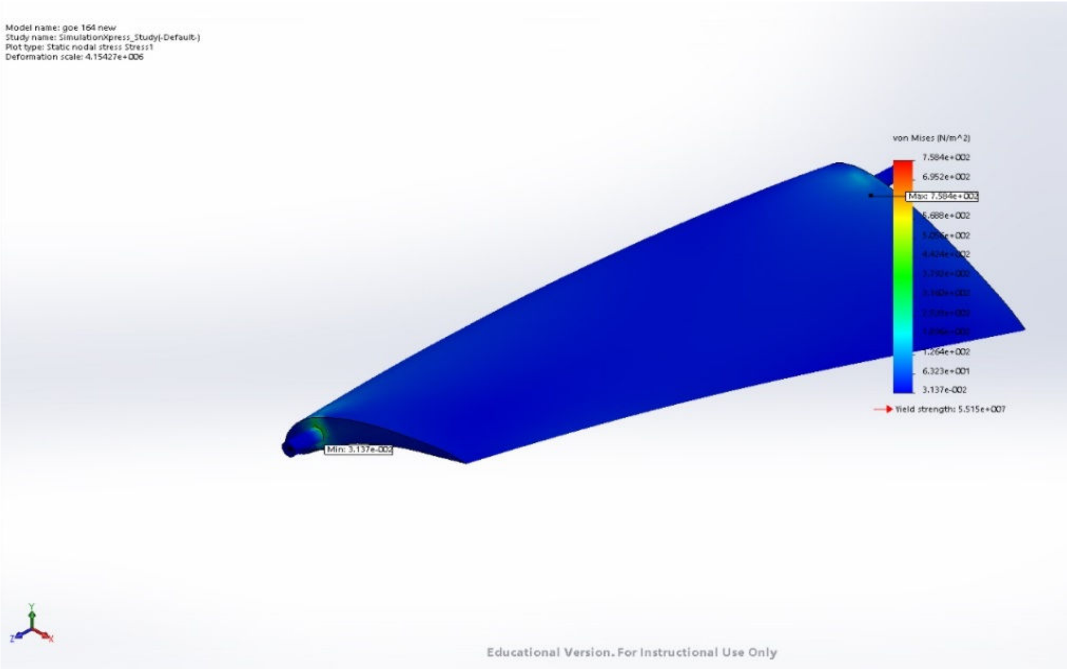


Figure 4.14: Stress analysis of blade part in wind turbine model

The above Figure 4.14 shows the Stress result of blade as it represents a scale which is result of every particular part of the blade starting from tip of left to right in Figure with minimum 0.0313722 N/m^2 and maximum 758.4 N/m^2 as VON: von Mises Stress analysis and then calculates the yield strength results as **5.515e+007** N/m^2.

Displacement Result of blade part in wind turbine model

Name	Type	Min	Max
Displacement	URES: Resultant Displacement	2.30521e-008 mm	0.000121454 mm

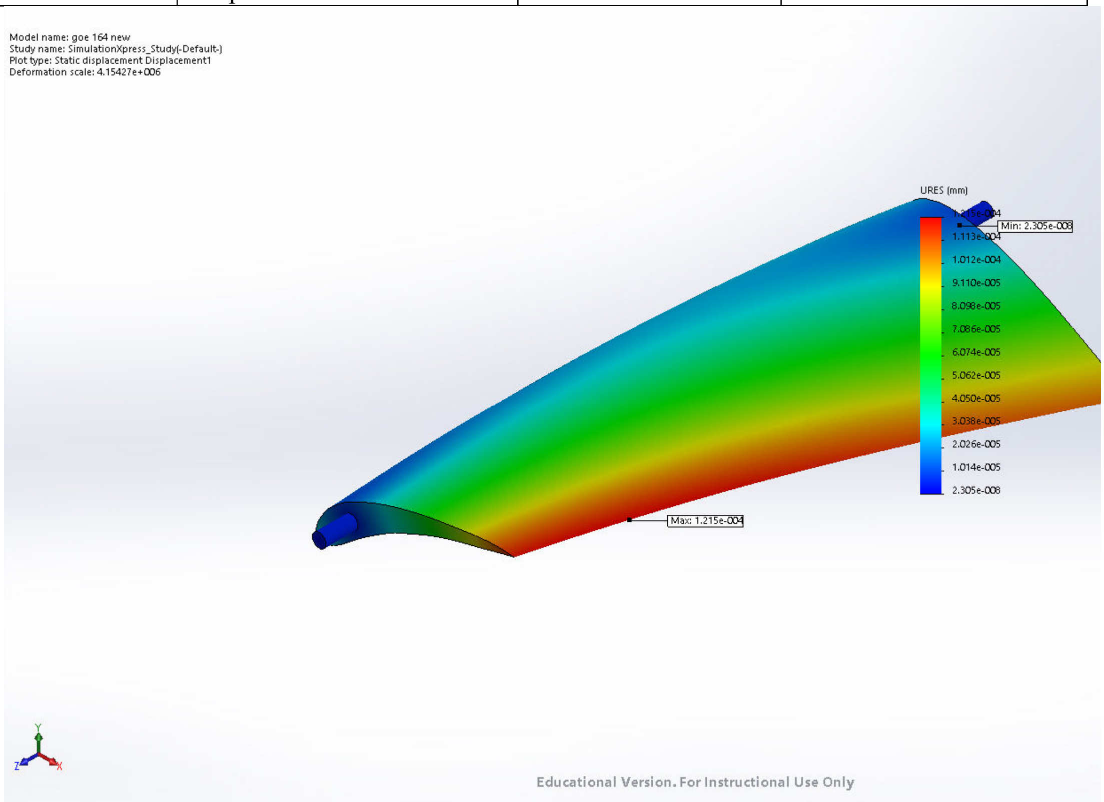


Figure 4.15: Displacement analysis of blade part in wind turbine model

The above Figure 4.15 shows the Displacement result of blade due to pressure applied on it which results a scale of deformation representing every part of the design with minimum 2.30521e-008 mm and maximum 0.000121454 mm as URES: Resultant Displacement analysis results.

Strain Result of blade part in wind turbine model

Name	Type	Min	Max
Strain	ESTRN: Equivalent Strain	4.96852e-013	8.72589e-009

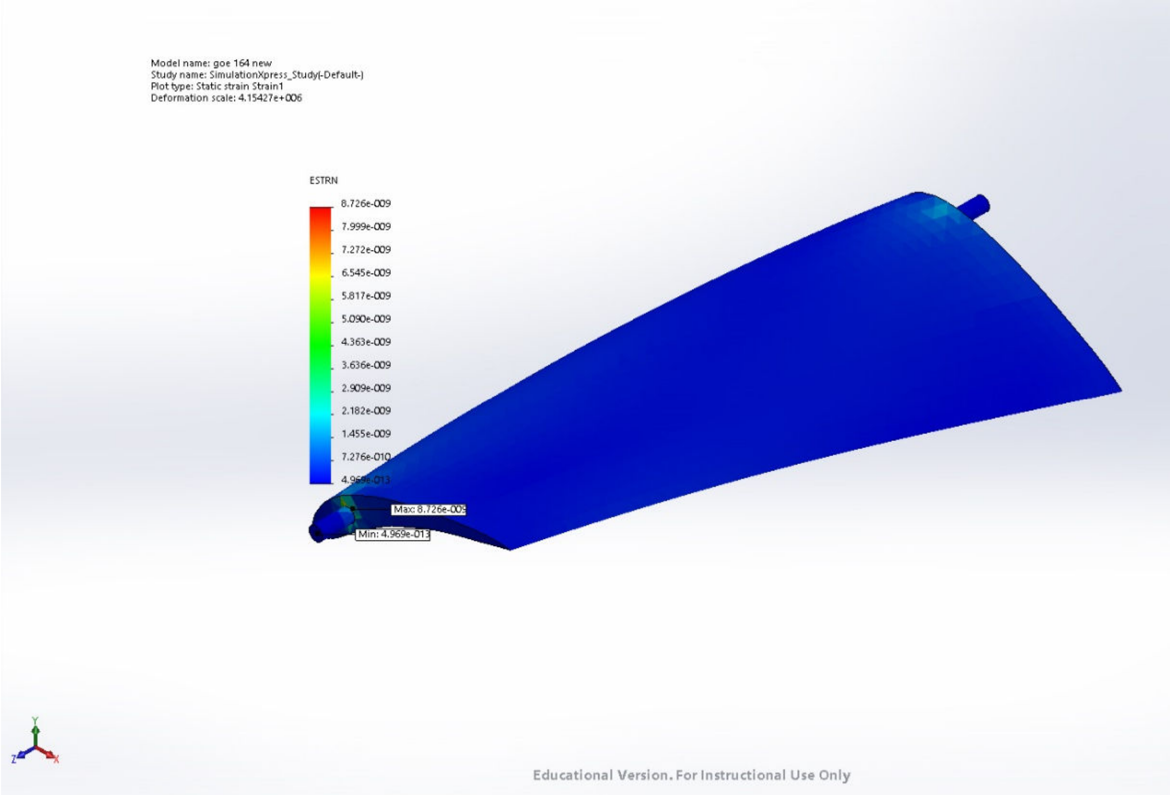


Figure 4.16: Strain analysis of blade part in wind turbine model

The above Figure 4.16 is the result of Equivalent Strain on shaft lock of the blade due to pressure applied on it which results a scale of Equivalent Strain representing every part of the shaft lock in design with minimum 4.96852e-013 and maximum 8.72589e-009 as ESTRN: Equivalent Strain analysis results.

4.3.2 Simulation of total assembled wind turbine model

Meshing Result of Total Assembled wind turbine model

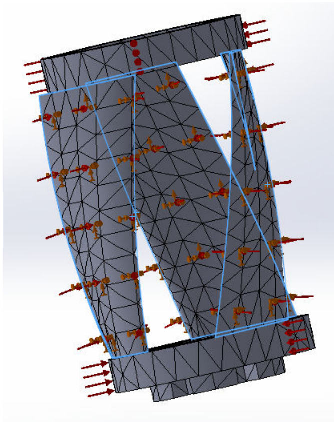


Figure 4.17: Meshing of Total Assembled wind turbine model

The above Figure 4.17 shows the meshing result of Total Assembled wind turbine model which results in, the edge and point for simulation of the total assembly during the natural parameters.

Stress Result of Total Assembled wind turbine model

Name	Type	Min	Max
Stress	VON: von Mises Stress	0.0N/m^2	11.2 N/m^2

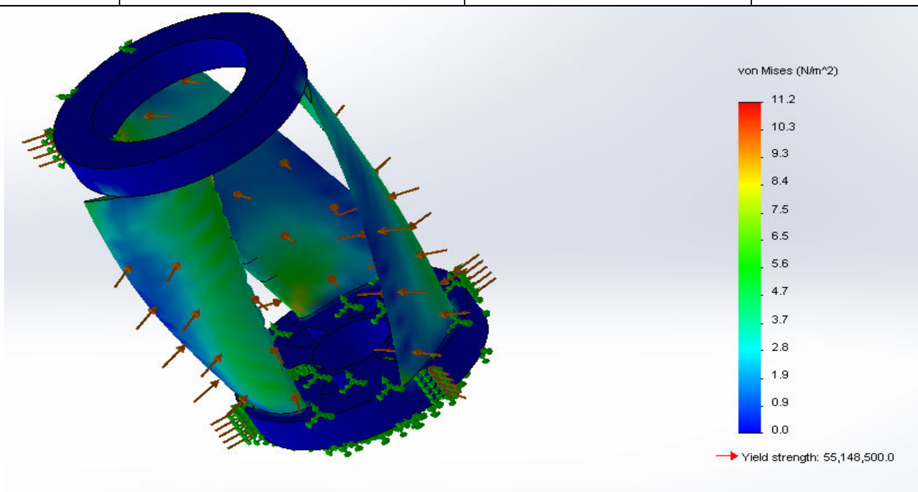


Figure 4.18: Stress analysis of Total Assembled wind turbine model

The above Figure 4.18 shows the von Mises Stress result of Total Assembled wind turbine model as it represents a scale which is result of every particular part of the blade starting from tip of left to right in figure with minimum 0.0N/m^2 and maximum 11.2 N/m^2 as VON: von Mises Stress analysis and then calculates the yield strength results as **55,148,500.0 N/m^2**.

Displacement Result of Total Assembled wind turbine model

Name	Type	Min	Max
Displacement	URES: Resultant Displacement	1.000e-030 mm	4.794e-007 mm

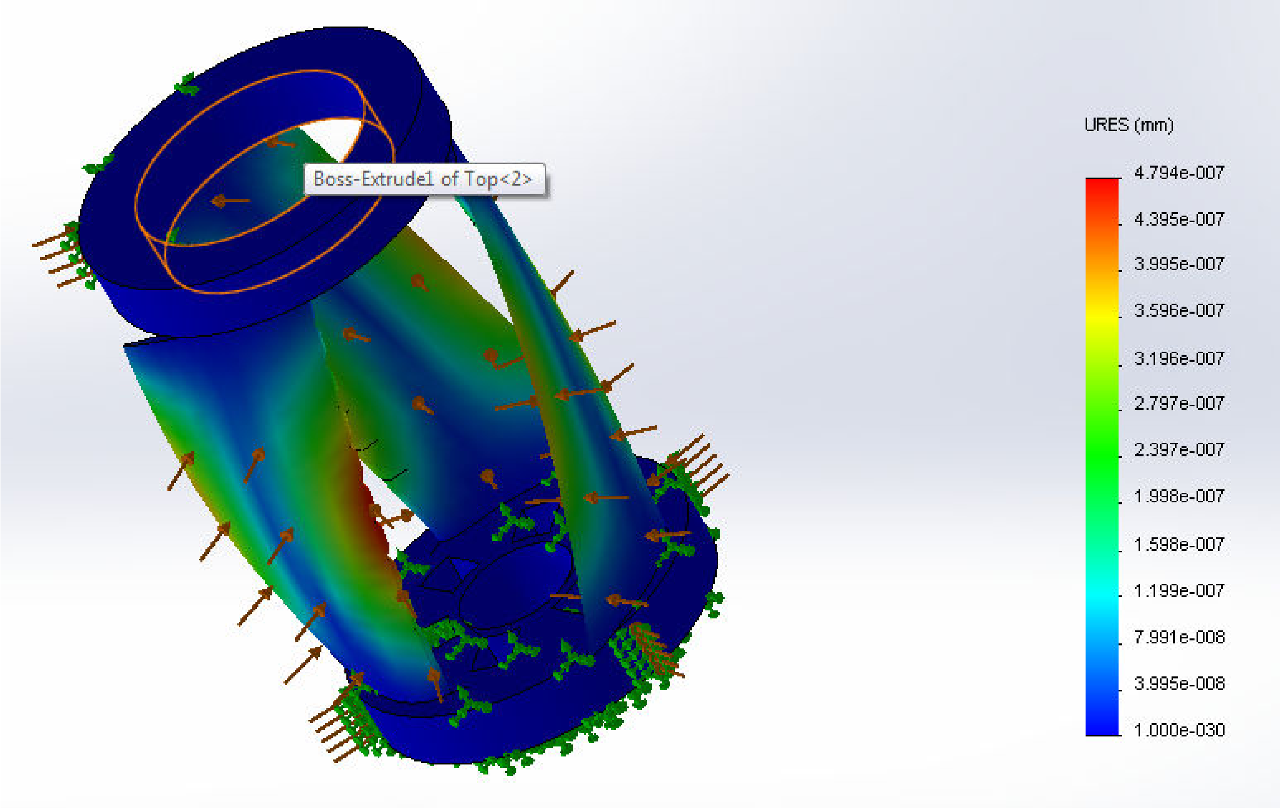


Figure 4.19: Displacement analysis of total assembled wind turbine model

The above Figure 4.19 shows the Resultant Displacement result of Total Assembled wind turbine model due to applied pressure on it which results a scale of deformation representing every part of the design with minimum 1.000e-030 mm and maximum 4.794e-007 mm as URES: Resultant Displacement analysis results.

Strain Result of Total Assembled wind turbine model

Name	Type	Min	Max
Strain	ESTRN: Equivalent Strain	9.187e-018	1.022e-010

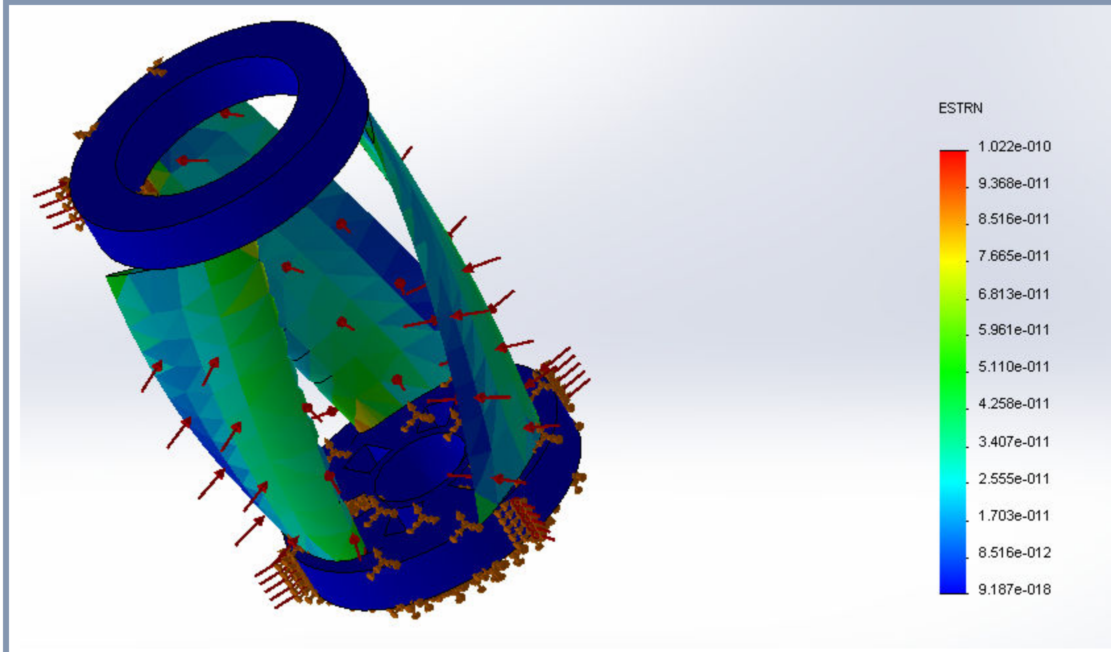


Figure 4.20: Strain analysis of total assembled wind turbine model

The above Figure 4.20 shows the result of Equivalent Strains on blade due to applied pressure works on model due to load on blade, which results a scale of Equivalent Strain representing every part of the blade in design with minimum 9.187e-018 and maximum 1.022e-010 as ESTRN: Equivalent Strain analysis results.

4.3.3 Air Flow Analysis of Wind Turbine model

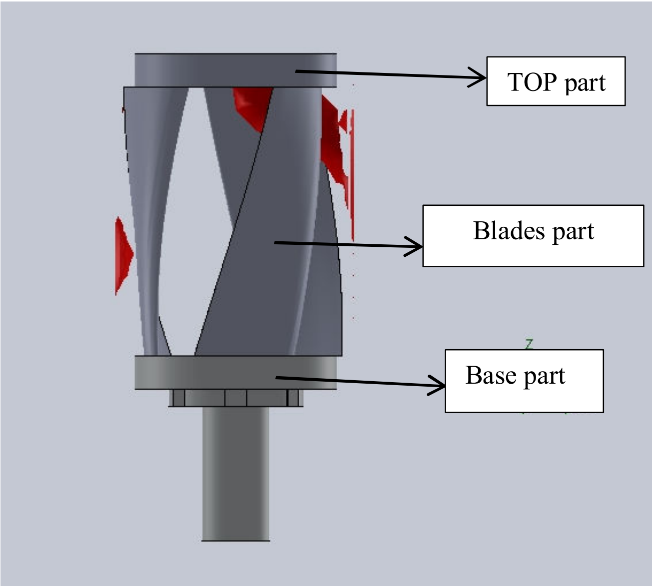


Figure 4.21: Iso-surface plot of total assembled wind turbine model

The above Figure 4.21 is Iso-surface plot of Total Assembled wind turbine model, which is the wind flow analysis of contact point on total assembly model of wind turbine.

NOTE: Iso-surface is a three-dimensional analog of an iso line. It is a surface that represents points of a constant value (e.g. pressure, temperature, velocity, density) within a volume of space.

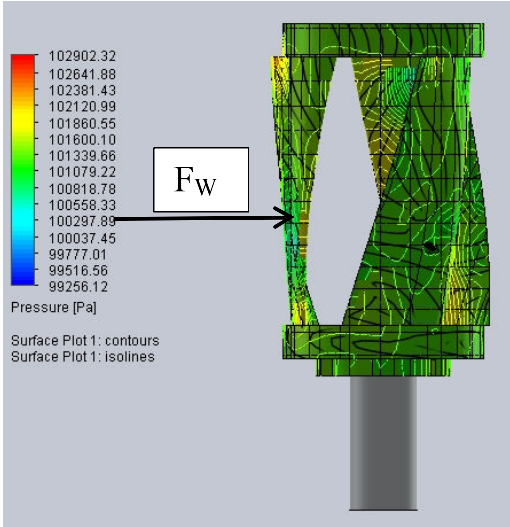


Figure 4-22: Pressure distribution plot of total assembled wind turbine model

The above Figure 4.22 is pressure distribution plot of Total Assembled wind turbine model, which is the natural wind pressure analysis on total assembly model of wind turbine with F_w = 10 m/s in X-axis direction of the figure.

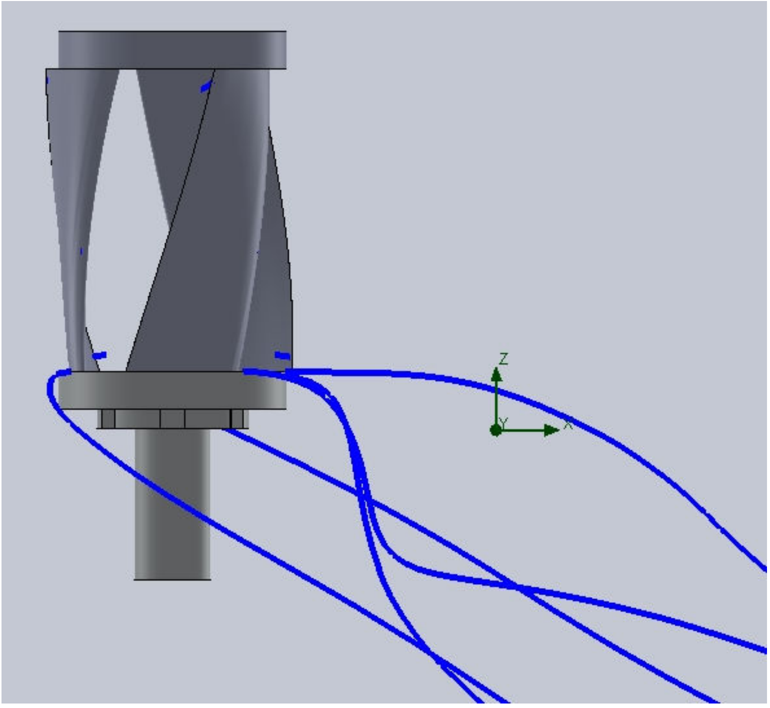


Figure 4.23: Flow trajectory plot of total assembled wind turbine model (Lag-rangian approach)

The above Figure 4.23 is Flow trajectory plot of Total Assembled wind turbine model, which is the natural wind particles analysis after in contacting the total assembly model of wind turbine according to Lag-rangian approach theory[22][23].

4.4 Technical Objectives of automated power transmission model utilized in present wind turbine model

The automatic power transmission system model can be very useful in low cost automation in all windmills. The speed working of pneumatic circuit is high. The power loss due time delay in transmission of gears is reduced.

4.4.1 Working Principle automated power transmission model

As the torque of wind turbine and the needle of the tachometer both varies. An IR sensor is embedded at each speed limit point in tachometer. As needle passes over IR sensor, an analog pulse is also generated. This pulse is converted to digital signal with the help of tachometer IC and is sent to the microcontroller.

The microcontroller senses the signal and develops an output logic which is delivered to motor driver IC. On receiving the logical signal the motor driven IC actuates the motor or actuator. Then next process actuator actuates the power transmission mechanism depending upon the speed of the wind turbine through optical tacho-sensor. Extra connection for power-supply of other accessories is provided in microcontroller. To do so a circuit model with microcontroller is constructed according to requirements in Orcad software platform as shown in Figure 4.24.

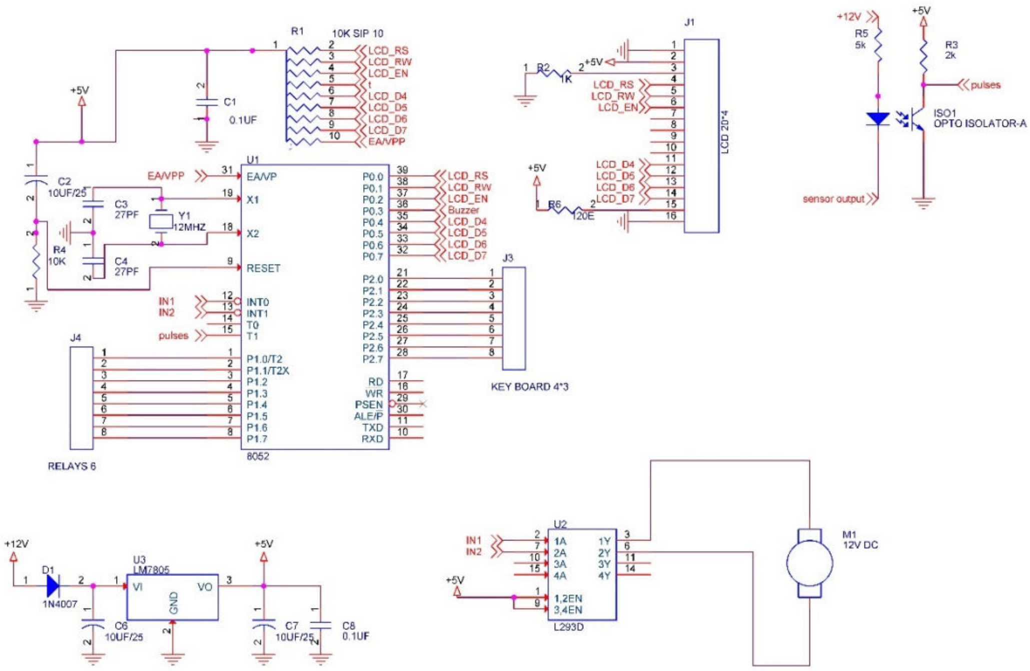


Figure 4-24: Schematic diagram of 8052 microcontroller with optical sensor circuit in orcad software.

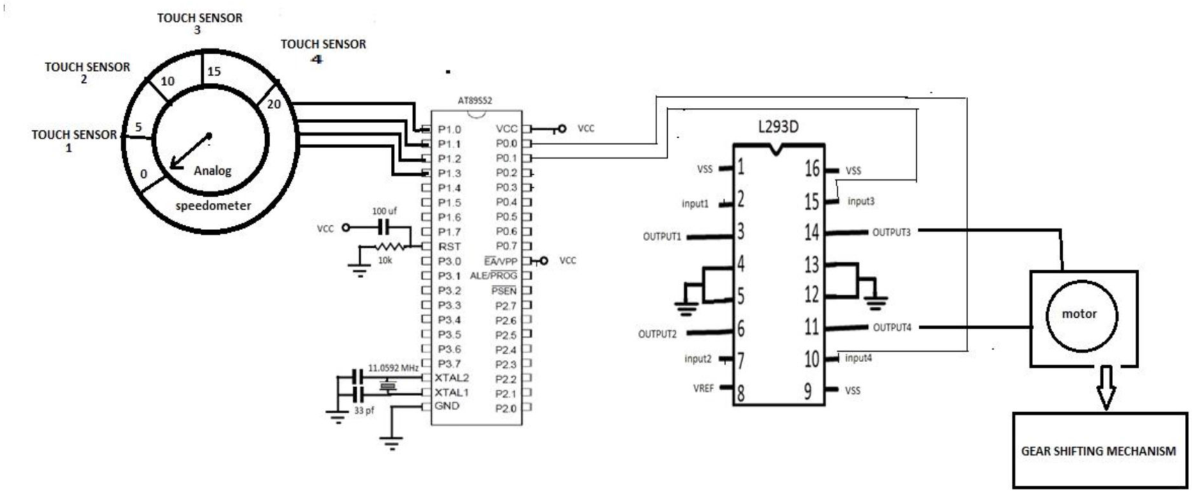


Figure 4.25: Circuit Diagram of Automatic power transmission Mechanism [24]

The main circuit is fixed near to the gear-box as shown in Figure 4.25. An air tank contains the compressed air already filled and placed near to gear-box for supply. The microcontroller in circuit is enable at the time of gear changing according to torque of tacho sensor, the solenoid valve is activated. The solenoid valve stem is open, the compressed air flow from the air tank to the pneumatic cylinder. The pneumatic cylinder piston moves forward at the time of compressed air inlet to the cylinder.

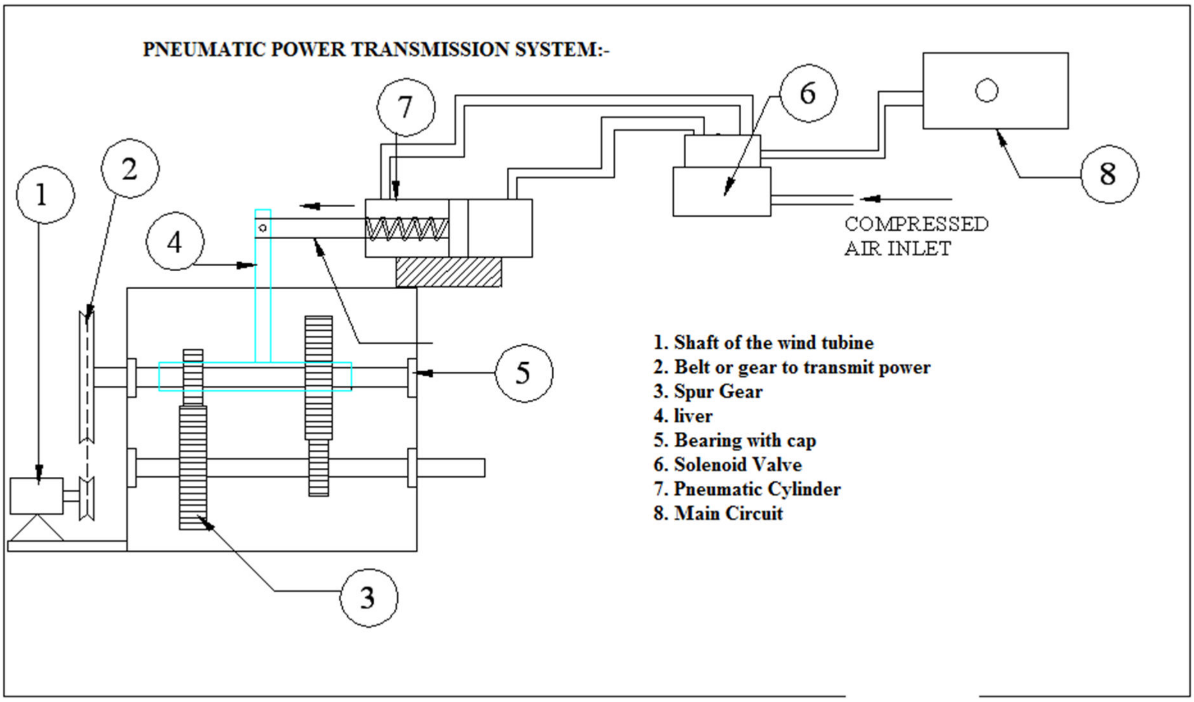


Figure 4.26: Pneumatic Diagram of Automatic Gear Shifting Mechanism [24]

The pneumatic cylinder moves the gear box liver automatically from one position to the another position. Then the gear box liver is activated, so that the gear-box output torque is constant for power production in generator.

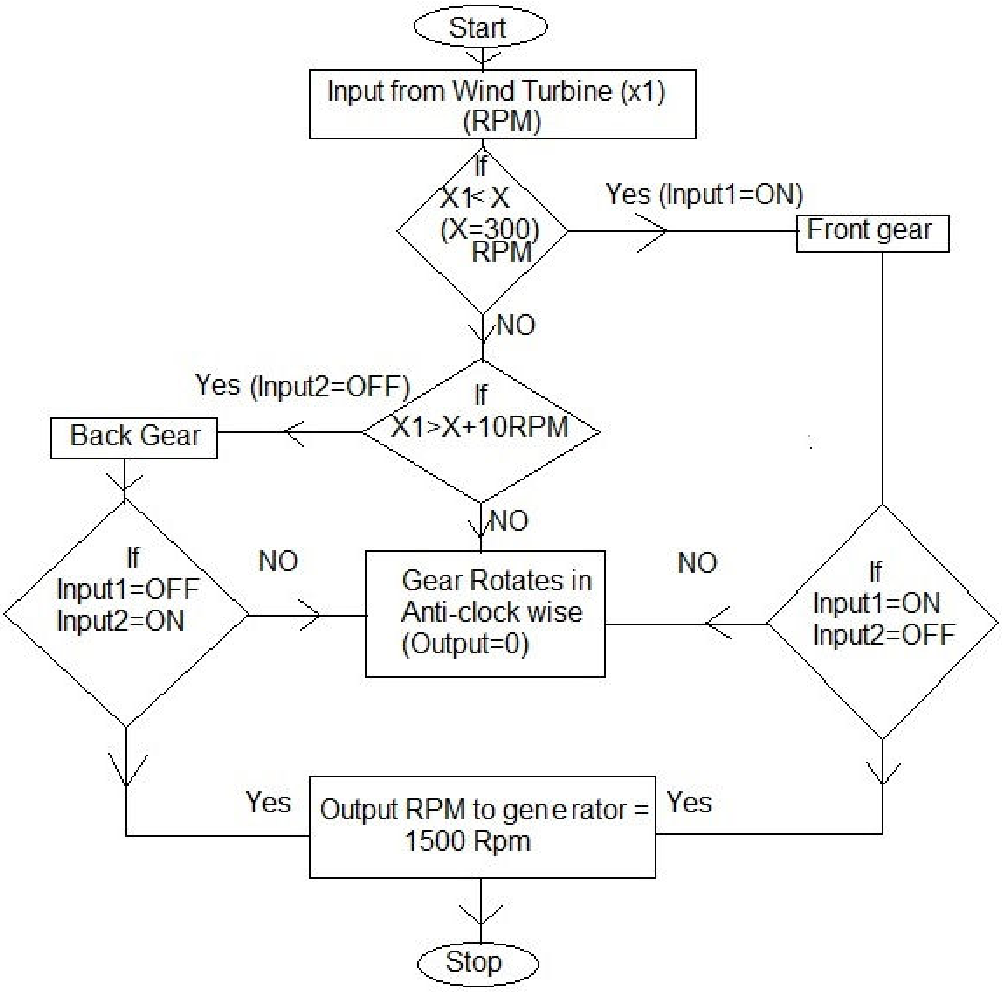


Figure 4.28: Algorithm for gear-box working

From Figure 4.28 an algorithm is prepared for microcontroller 8052 in order to control pneumatic cylinder operates the power transmission liver automatically from one position to the another position and the program is created using code keil software platform. Then the power transmission liver is activated, so that the power transmission model output torque is constant for power production in generator.

Applications

- It is very much useful for house-hold & industrial power usage.
- Thus it can be useful for the continuous power usage applications.

4.4.2 Technical Explanation of parts used for power transmission model

- **Microcontroller 8052**

  The 8052 is an 8-bit microcontroller originally developed by Intel in the late 1970s. It includes an instruction set of 255 operation codes (**opcodes**), 32 input/output lines, three user –controller timers, an integrated and automatic serial port [25].

  It is a slightly more powerful microcontroller, sporting a number of additional features which the developer may make use of

  1. 256 bytes of Internal RAM (compared to 128 in the standard 8051).
  2. A third 16-bit timer, capable of a number of new operation modes and 16-bit reloads.
  3. Additional SFRs to support the functionality offered by the third timer

- **Optical Tachometer sensor**

  Tachometer is a device used for the measurement of rpm of the wind mill. We can use an optical tachometer having a different speed range according to our required rpm [26].

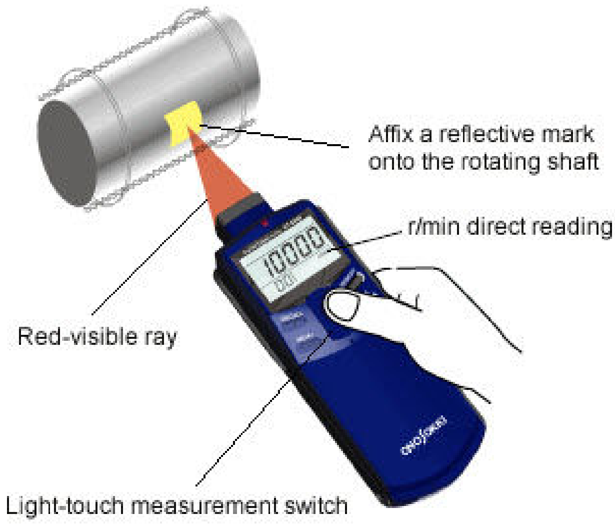


Figure 4.29: Working of tachometer [27]

- **Solenoid Valve**

Solenoid valves are electrically actuated mechanical systems that control the flow of substances like liquids and gases. Solenoid valves are commonly used on automotive transmissions. The solenoid valve uses an electric current which moves the solenoid. This pulls a piston preventing it from stopping the flow of air and fluid. The valve will need a constant flow of electrical current to remain open because when there is no current flow, the electromagnetic field scatters and the valve returns to its original position [28].

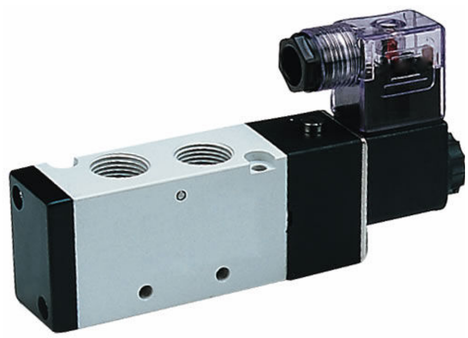


Figure 4.30: Solenoid Valve [29]

- **Liquid Crystal Display**

Liquid crystal display, a type of display used in digital watches and many portable computers. LCD displays utilize two sheets of polarizing material with a liquid crystal solution between them. An electric current passed through the liquid causes the crystals to align so that light cannot pass through them. Each crystal, therefore, is like a shutter, either allowing light to pass through or blocking the light. The following Figure shows the representation of a LCD [28].

Figure 4.31: Liquid crystal display [30]

- **Relays**

A relay is an electrically operated switch. Relays are used where it is necessary to control a circuit by a low power signal (with complete electrical isolation between control and controlled circuits), or where several circuits must be controlled by one signal. The following Figure 4.32 shows the schematic diagram of a relay [28].

Figure 4.32: Relays [31]

When no voltage is applied to pin1, there is no current flow through the coil. No current means no magnetic field is developed, and the switch is open, when voltage is supplied to pn1, current flow through the coil creates the magnetic field to close the switch allowing continuity between 2 and 4. The following Figure 4.33 shows the operation of a relay [28].

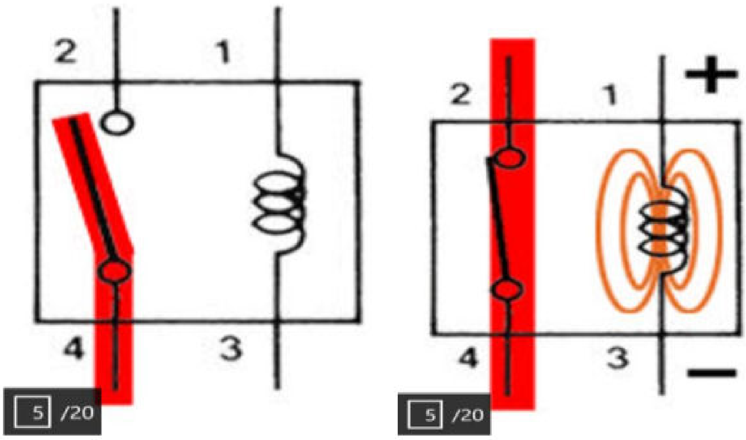


Figure 4.33: Operation of a relay [32]

4.5 Total Estimated Working Assembly Model of Wind Turbine with Automated Gear-Box

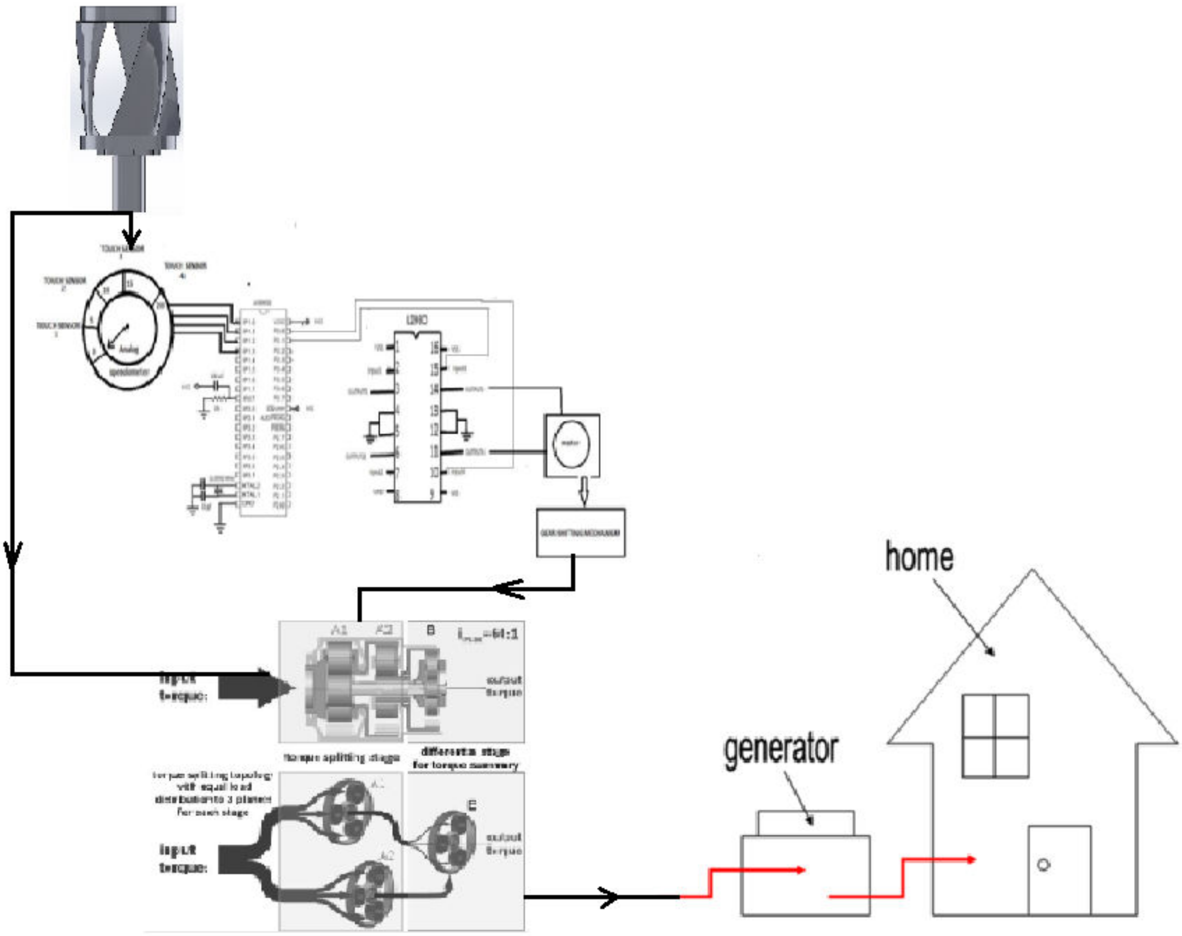


Figure 4.34: Total estimated working assembly model

Above Figure 4.34 explains the estimated working model of the wind turbine concept on which the following total report has been built where, it could help in supplying to house-hold power usage.

It explains the torque generated from wind turbine due to contact with air which is transferred to the gear-box with the help of microcontroller, the gears make the decision of power transmission in order to produce required amount of power to the generator.

Therefore the generator produces electricity for house-hold usages.

5 Conclusion

The concept of designing new model of a wind turbine by concentrating on modifying the blade design for a small scale wind turbine was achieved. It was found that a VAWT (Vertical Axis Wind Turbine) is more efficient than a HAWT (Horizontal Axis Wind Turbine) for small scale electricity usage. So, a VAWT wind turbine blade was designed based on Vertical Axis Wind Turbine.

Tasks achieved in this project are:

1. The designing the turbine blade using of GOE (Gottingen) 164 profile and the turbine's other supporting parts of blade like Top Part and Base part was achieved. After it the total assembling of the wind turbine with different model parts was done.
2. As the purpose of mechanical analysis, simulations tests like Von Mises stress, Strain Distribution & Displacement were carried out and results of total assembled wind turbine were extracted they are :
   - Yield strength obtained as 55,148,500.0 N/m^2
   - Resultant Displacement as Minimum 1.000e-030 mm & Maximum 4.794e-007 mm respectively
   - Equivalent Strain as Minimum 9.187e-018 & Maximum 1.022e-010.
3. Creation of automatic power transmission model for wind turbine model.

   The automation of power transmission model was carried out by incorporating a PLC circuit consisting of 8052 micro-controller, the structure is constructed in ORCAD software platform and checked using ISIS software.

   After it a program was design and tested in CODEKEIL software platform. Hence this total automation results a constant and standard output.

In total it can be concluded that the prescribed vertical axis wind turbine model with automation of power transmission model will be the next step to reduce investment costs and optimize cost of energy for an independent power production.

6 Reference

[1] Tony Burton, David Sharpe, Nick Jenkins, Ervin Bossanyi: *Wind Energy Handbook*, John Wiley & Sons, 2nd edition (2011), ISBN 978-0-470-69975-1

[2] Image Source: Copyright © 2008 RnR Energy Ltd. Available at http://www.rnrenergy.ca/typesofwindturbines.htm

[3] Article from http://centurionenergy.net/how-wind-turbines-work by C Bracken Meyers on 09 December 2013 03:05.

[4] Image Source: Copyright 2014 Dylan Ratigan. Available at http://www.dylanratigan.com/2012/05/08/the-often-overlooked-jellyfish-inspiring-innovation-at-caltech/

[5] Article from http://centurionenergy.net/how-wind-turbines-work by C Bracken Meyers on 09 December 2013 03:05.

[6] Image Source: Courtesy of Aluminum Company of America. From http://centurionenergy.net/how-wind-turbines-work by C Bracken Meyers on 09 December 2013 03:05.

[7] Image Source: taken by photographer Jaganath and Available at http://commons.wikimedia.org/wiki/File%3ASavonius_turbine.svg

[8] Article from http://centurionenergy.net/how-wind-turbines-work by C Bracken Meyers on 13 October 2012 22:10.

[9] Image Source: File Available at internet :Equal_transit-time_NASA_wrong1.gif

[10] Image Source: private site by eolicoefficiente.

[11] M.Ragheb, "Wind Power Systems Harvesting the Wind." https://netfiles.uiuc.edu/mragheb/www, 2011.

[12] 2013. WAsP - the Wind Atlas Analysis and Application Program. Accessed October 2013.http://www.wasp.dk/.

[13] Developing wind power projects by Tore Wizelius in 2015 by Routledge, new York, NY 10017 (pages 19-25).

[14] Generatori eolici per la connessione alla rete by F. Spertino.

[15] Article from: The Impact of Control Technology, T. Samad and A.M. Annaswamy (eds.), 2011.

[16] Created profile details on http://airfoiltools.com/airfoil/details?airfoil=goe164-il#polars

[17] Aalco is a registered trademark of Aalco Metals Ltd Copyright: Aalco Metals Ltd, 25 High Street, Cobham, Surrey KT11 3DH on 03 December 2013.

[18] Article from paper by Heinz Rongen Forschungszentrum Jülich Zentrallabor für Elektronik.

[19] Image Source: Available at http://www.festo.com/wiki/rep/File:Zylinder_einfachwirkend.png.

[20] Image Source: Available at http://www.festo.com/w/rep/images/8/8d/Zylinder_doppeltwirkend_eingefahren.png.

[21] Created profile details on http://airfoiltools.com/airfoil/details?airfoil=goe164-il#polars

[22] V.I Arnold, Lagrange and Legendre cobordism, Functional Analysis and Application, 14(1980), 167–177, 252–260.

[23] Goldstein, Herbert; Poole, Charles P.; Safko, John L. (2002). Classical Mechanics (3rd ed.). Addison-Wesley. p. 21. ISBN 978-0-201-65702-9.

[24] research article on "Automatic Gear Shifting Mechanism and Electric Drive in a Bicycle" by P.D. Kamble, S.P. Untawale and S.B. Sahare from VSRD-MAP, Vol. 2 (4), 2012, 125-139..

[25] "The 8051/8052 Microcontroller" by Craig Steiner in 2005.

[26] http://www.oros.com/5436-rpm-and-phase-measurement-for-rotating-machinery.htm

[27] Image Source: Available at https://www.elprocus.com/wp-content/uploads/2014/03/319.jpg

[28] IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 11, Issue 3 Ver. V (May- Jun. 2014), PP 53-63

[29] Image Source: Available at http://namayeshgah.com/files/8202/Products/30199-MedPic.jpg

[30] Image Source: Available at http://www.circuitstoday.com/liquid-crystal-displays-lcd-working

[31] Image Source: Available at http://static.rapidonline.com/catalogueimages/Module/M029535P01WL.jpg

[32] Image Source: Available at http://static.rapidonline.com/catalogueimages/Module/M029535P01WL.jpg

[33] Dietrich Lohrmann, "Von der östlichen zur westlichen Windmühle", *Archiv für Kulturgeschichte*, Vol. 77, Issue 1 (1995), pp.1-30 (10f.)

Appendix 1: Information about aero foil used in blade of wind turbine model

The GOE 164 is also known as Gottingen 164 was used as a blade profile. The GOE 164 has a wedge-shaped drag polar. To extract the aero foil profile of the blade in solid works which is main part of wind turbine design model we used co-ordinates from the following figure A-1 generated in online aero foil creator.

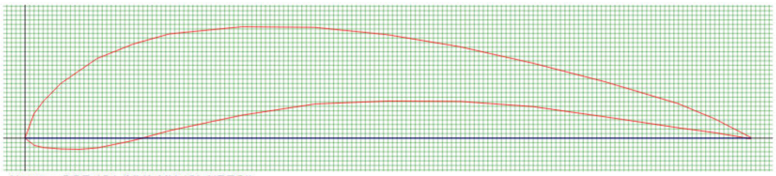
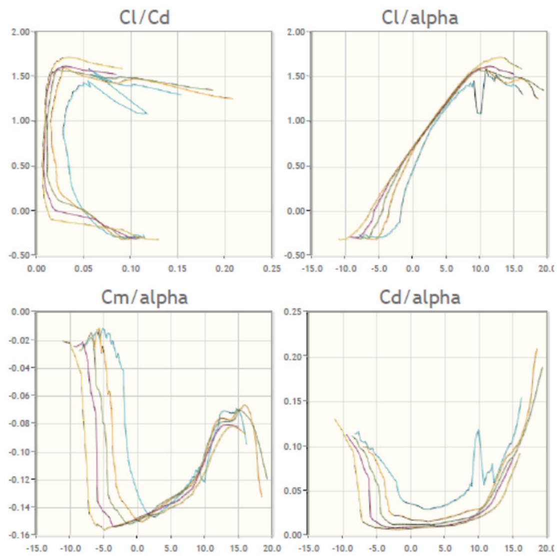


Figure A1.1: Modified Aero foil created from online site.

GOE 164 AIRFOIL CO-ORDINATES

Airfoil surface	
X (mm)	**Y (mm)**
1372.842	274.4211
1286.042	299.1708
1200.865	316.1682
1034.273	331.8247
869.0355	340.9232
704.8168	345.0612
542.5337	339.7962
382.3377	324.4486
225.1436	294.5021
71.39458	247.8916
-2.54285	210.3538
-74.5962	163.6719
-108.316	129.1421
-142.04	94.63581
-173.095	47.20189
-187.311	17.13881
-196.157	-39.0181
-173.355	-50.5594
-152.739	-51.5239
-112.853	-46.8447
-73.4629	-39.8414
-34.9043	-28.8192
40.20859	3.055009
114.3022	39.88972
264.6607	104.4477
416.3631	159.4604
572.0009	196.9033
729.1014	227.3205
888.3296	247.3696

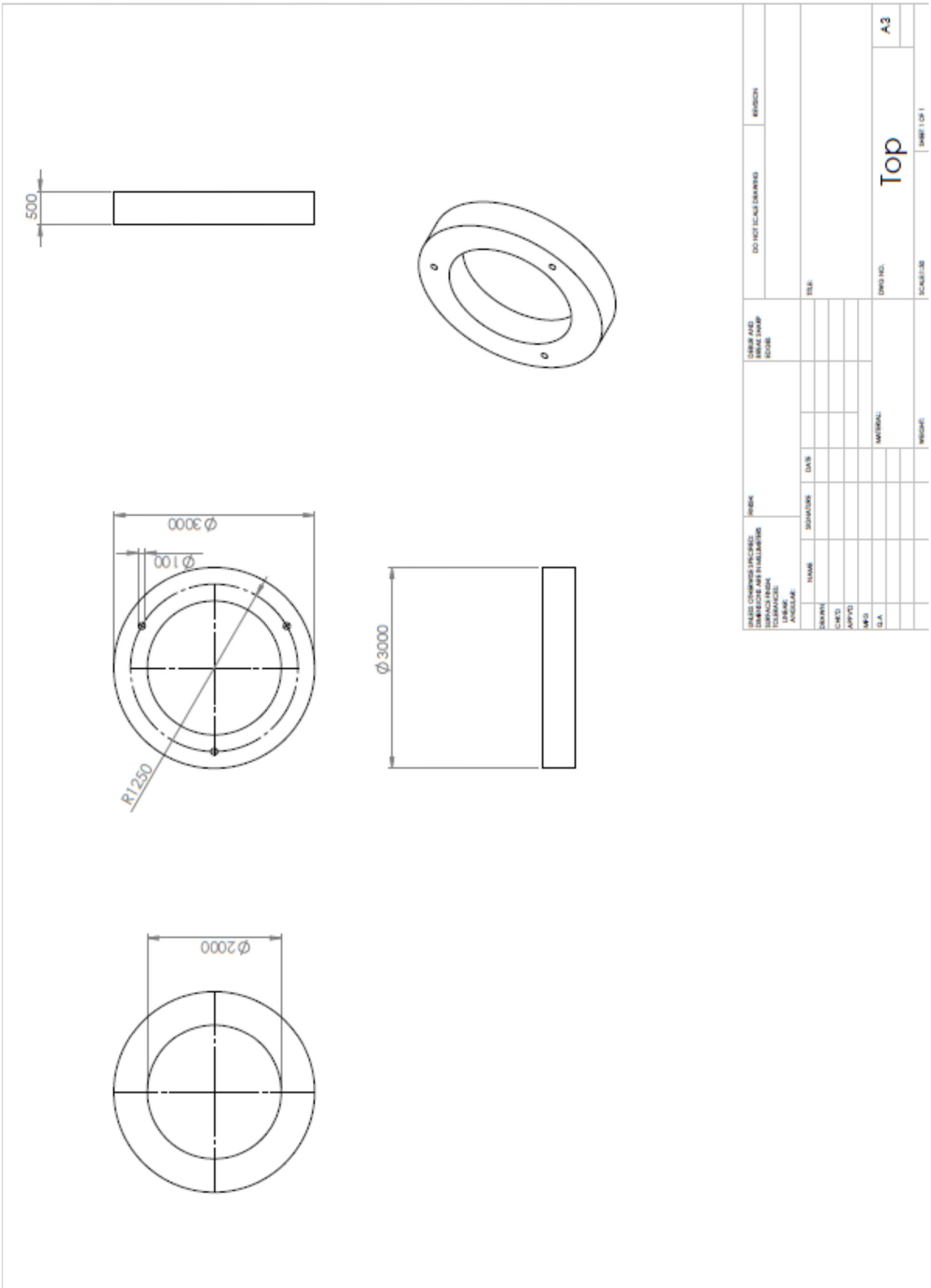
1049.816	256.3915
1211.573	264.2192
1292.208	269.3201
1373.357	271.8318
Camber line	
X (mm)	**Y (mm)**
-196.157	-39.0181
-182.107	-9.02462
-163.279	-2.14407
-127.957	23.83569
-91.488	44.54388
-55.414	67.2366
18.13334	106.4076
92.15065	143.5438
244.113	199.1361
398.7874	241.7503
556.7691	268.2299
716.5428	286.1103
878.3483	294.1043
1041.779	294.0932
1206.033	290.1847
1289.012	284.2383
1373.099	273.1265
Chord line	
X (mm)	**Y (mm)**
-196.157	-39.0181
1373.099	273.1265



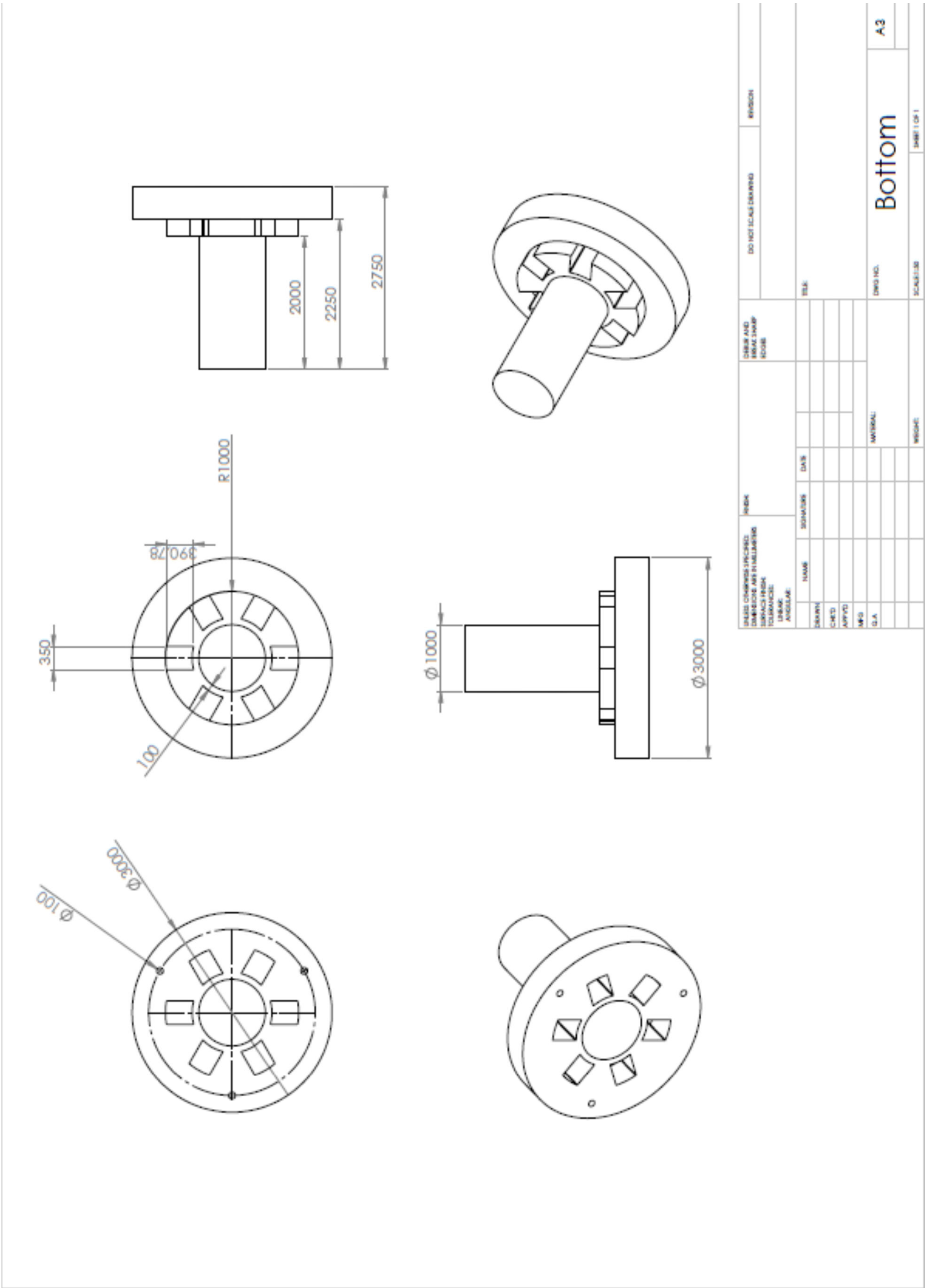
FigureA1.2: GOE 164 AIRFOIL profile performance of Cl, Cd, Cm & alpha ranges Graphs on air flow contact on blade

Appendix 2: Designs created in wind turbine model

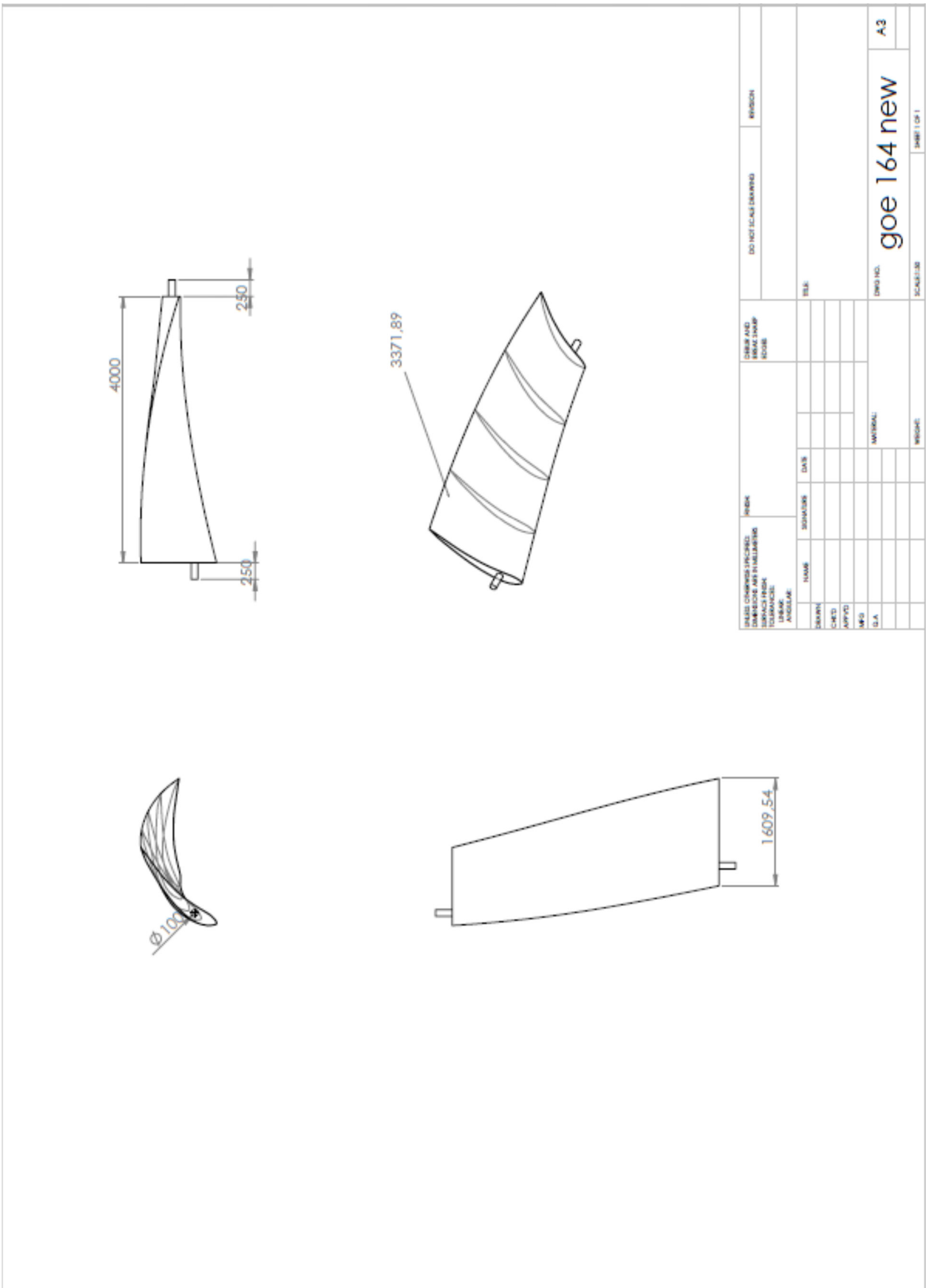
1. Top part design of wind turbine model



2. Base part design of wind turbine model



3. Blade part design of wind turbine model



Appendix 3: Program created for automation of power transmission model

The program created and executed in code keil software, in order to use it in automation of power transmission. It is shown in below written program

```
#include <at89x52.H>
#include "Delay.H"
#include "LCD.H"
#include "KEYBOARD.H"
sbit IN1=P3^6;
sbit IN2=P3^7;  //CONTROL REALY MAIN
#define ON 0
#define OFF 1
bit flagT0;
volatile unsigned long int pulses,RPM,GIVENRPM;
volatile unsigned int x2,x3,x4,x5,x;
volatile unsigned char d1,d2,d3,d4,d5,d6;//,div_factor;
volatile int mil_sec;
/* Function define */
void init_timers(void);
void GET_Frequency(void);
void check();
void click_backgear();
void click_frontgear();
unsigned char gearposition,oldposition;
void init_timers(void)
 // Timer0 as a Timer and Timer1 as a Counter
{
//Configure and Enable timer.
//Timer Clk=12/12*1 = 1.0 MHz 1msec delay
     T1=1; //make to an input
     TMOD=0xD1; //T0 as a counter
     TL0=0xF0; TH0=0xD8;
     TL1=TH1=0;
     TR0=1; //start timer
     TR1=1; //start timer
     ET0=1;
     ET1=1;
     EA=1; /* enable interrupts */
}
void timer_0 () interrupt 1          //Timer
{
     mil_sec++;
     if(mil_sec>100)
     {
                flagT0=1;
                mil_sec=0;
     }
     TL0=0xF0; TH0=0xD8;
     TR0=1;
}
```

```
void GET_Frequency(void)
{
     pulses=((TH1<<8)|(TL1));
     LCDIntXY(pulses,5,0,1);
     LCDStringXY(" RPS",5,1);
     RPM=(pulses/60);
     LCDIntXY(RPM,5,0,0);
     LCDStringXY(" RPM",5,0);
}
void main(void)
{
                P3=0xff;P2=0XFF;P1=0x00;mil_sec=0;
                P2=0xFF;
                flagT0=0;
                init_timers();
                EA=0;
                LCD_init();
     //         LCDStringXY("LCD init.. ",0,0);
     //         _delay_ms(500);
                LCD_Data(0x01,0);
                gearposition=oldposition=0;
                LCDStringXY("WIND MILL GEAR",0,0);
                LCDStringXY("    SYSTEM    ",0,1);
                _delay_ms(10);
                LCD_Data(0x01,0);
                GIVENRPM=60;
                RPM=0;GET_Frequency();
                EA=1;
     while(1)
     {
                if(flagT0)
                {

                           EA=0;TR0=TR1=0;TL0=0xF0; TH0=0xD8;
                           GET_Frequency();
                           check();
                           TL1=TH1=0x00;
                           TR0=TR1=1;flagT0=0;
                           EA=1;
                }

                P2=0xF0;
                if(P2!=0xF0 && key_scan()=='*')
                {
                           LCDStringXY("RPM VALUE=",0,0);
                           _delay_ms(2);
                           GIVENRPM=kscan_digit(2);
                           LCD_Data(0x01,0);
                           GET_Frequency();
          }

     }
}
```

```
void check()
{
   //run timer 2
   if(RPM>GIVENRPM && RPM<(GIVENRPM+10))
   {
      //OK
   }
 else if(RPM<GIVENRPM)
   {
      click_frontgear();
   }
   else if(RPM>GIVENRPM+10)
   {
      click_backgear();
   }
}
void click_frontgear()
{
   IN1=OFF;IN2=ON;//clock wise
//wait 1.5 sec
   _delay_us(1500);
   IN1=OFF;IN2=OFF;//anticlock wise
//wait 0.8 sec
   _delay_us(800);
   IN1=IN2=OFF;
}
void click_backgear()
{
   IN1=ON;IN2=OFF;//anticlock wise
//wait 1.5 sec
   _delay_us(1500);
   IN1=OFF;IN2=OFF;//clock wise
//wait 0.8 sec
   _delay_us(800);
   IN1=IN2=OFF;
}
```