ŠIAULIŲ UNIVERSITETAS
TECHNOLOGIJOS, FIZINIŲ IR BIOMEDICINOS MOKSLŲ FAKULTETAS
MECHANIKOS IR STATYBOS INŽINERIJOS KATEDRA

Vinay, Kuruvalli Nemakal

Harith, Ramesh Mynavathy

VĖJO SRAUTO GAUDYKLĖS PARAMETRŲ TYRIMAS

Magistro darbas

ŠIAULIAI, 2016

ŠIAULIŲ UNIVERSITETAS
TECHNOLOGIJOS, FIZINIŲ IR BIOMEDICINOS MOKSLŲ FAKULTETAS
MECHANIKOS IR STATYBOS INŽINERIJOS KATEDRA

TVIRTINU

Katedros vedėjas

2016-06-02

VĖJO SRAUTO GAUDYKLĖS PARAMETRŲ TYRIMAS

Magistro darbas

Vadovas

Doc. Dr. Dalia Čikotienė
Doc. Dr. Artūras Sabaliauskas
2016-06-02

Recenzentas

Doc. Dr. Raimondas Šniuolis
Doc. Dr. Sergėjus Rimovskis

2016-06-02

Atliko
MM-14 gr. stud.

Vinay, Kuruvalli Nemakal
Harith, Ramesh Mynavathy

2016-06-02

ŠIAULIAI, 2016

ŠIAULIŲ UNIVERSITY
FACULTY OF TECHNOLOGY, PHYSICAL AND BIOMEDICAL SCIENCES
MECHANICAL AND CIVIL ENGINEERING DEPARTMENT

Vinay, Kuruvalli Nemakal
Harith, Ramesh Mynavathy

INVESTIGATION OF PRAMETERS OF WIND FLOW CATCHERS

Master Thesis

ŠIAULIAI, 2016

ŠIAULIŲ UNIVERSITETAS
FACULTY OF TECHNOLOGY, PHYSICAL AND BIOMEDICAL SCIENCES
MECHANICAL AND CIVIL ENGINEERING DEPARTMENT

APPROVED

Head of Department
2016-06-02

INVESTIGATION OF PRAMETERS OF WIND FLOW CATCHERS

Master Thesis

Guide

Doc. Dr. Dalia Čikotienė
Doc. Dr. Artūras Sabaliauskas

2016-06-02

Evaluator

Doc. Dr. Raimondas Šniuolis
Doc. Dr. Sergėjus Rimovskis

2016-06-02

Conducted
MM-14 gr. stud.

Vinay, Kuruvalli Nemakal
Harith, Ramesh Mynavathy

2016-06-02

ŠIAULIAI, 2016

ACKNOWLEDGEMENT

We take this opportunity to thank Šiauliai University for the support.

We take this opportunity to thank Doc. Dr. Dalia Čikotienė and Doc. Dr. Artūras Sabaliauskas (Guides) for providing continuous support throughout the project.

We express our profound gratitude to our mentor Doc. Dr. Raimondas Šniuolis who has been constant source of guidance and support.

We are thankful to Doc. Dr. Sergėjus Rimovskis, who has always been our mentor and helped me in the technical aspects of the thesis.

We are also grateful to Doc. Dr. Alfred Lankauskas, who has guided us through the basics and the theoretical aspect of the thesis work.

We also take this opportunity to thank our parent's for their moral support and believing us.

APPROVED
Head of Department

___________________________ Loreta Kelpšienė
02/ 06 / 2016

TASK OF MASTER THESIS

For Vinay, Kuruvalli Nemakal; Harith, Ramesh Mynavathy

Theme **INVESTIGATION OF PRAMETERS OF WIND FLOW CATCHERS**

Approved by department session protocol No TFBMSIKP-5 at 04/04/2016.

1. Aim of the master thesis

The aim of work is to investigate prameters of wind flow catchers on the roof of train and near railway.

2. The structure of the master thesis

Introduction. Review of wind turbine. Field of invention. Investigation of parameters of harnessing wind energy by arrangement of wind turbines. Proposed model wind turbine design. Conclusion. References.

Date of project graduation 9/6/2016.

The task got Vinay, Kuruvalli Nemakal ______________________
(name, midle name, surname) (Signature, date)

The task got Harith, Ramesh Mynavathy ______________________
(name, midle name, surname) (Signature, date)

Supervisor assoc. prof .dr. Dalia Čikotienė ______________________
(academic title, name, surname) (Signature, date)

Supervisor assoc. prof .dr. Artūras Sabaliauskas ______________________
(academic title, name, surname) (Signature, date

THEAM AND GOALS OF THE MASTER THESIS

THEME:

To identify a clean source of energy in order to generate electricity using this clean and renewable source as input energy. The depleting conventional energy sources and also the damage caused by these sources to the environment leads us to come up with innovative ideas to overcome the scarcity of such sources in the near and distant future, also to find continuous sources of energy which can replace these conventional energy sources when they are completely consumed. This paper aims into identifying such renewable and ecofriendly energy sources, and using suitable methods to harness them, so as to generate electricity as an output.

GOALS:

- To identify a valuable source of clean, renewable and environmental friendly input energy.
- To calculate the amount of energy in units in relation with the time factor that can be wisely and safely utilized.
- To examine the possibilities and locations where the power generation can be obtained.
- To calculate various input parameters for safe working.
- To perform theoretical calculations and virtual flow simulations with the basic data.
- To compare various models for using in the suitable environment.
- To estimate the output available.
- To tabulate and compare the results.

ABSTRACT

This thesis attempts to explain an innovative method of generating clean energy from a fast moving vehicle (train) by various courses. The energy generated from this method is produced as the consequences of human activity. The methods used to produce energy are from wind and excreta available from a moving train. One of the biggest obstacles to the widespread use of wind power generation is that many areas just aren't that windy. The alternative form of wind energy produced by trains is very unique, as it does not depend on any natural energy resource. A moving train compresses the air in the front of it and pushes the air to its sides thereby creating a vacuum at its rear and its sides as it moves forward. To fill up this vacuum a mass of airflow rushes into the sides and the rear. The kinetic energy of the wind movement thus created is used to generate electricity. This generated electricity can be further used for various applications.

The aim is to produce electricity by using the concept of the rotation of wind turbine due to the wind caused by the moving train and also by using an electrical power generation system. As anyone living near railway tracks will tell you, speeding trains generate quite a bit of wind as they whoosh past. The idea is to design a wind turbine that can be installed next to the track, and as the train passes. The wind drives a turbine to generate electricity. These devices could be placed along railway or subway lines, and make good use of an otherwise wasted resource. An electrical power generation system comprises a variable capacitor and a power source. The power source is used in the form of a generator to prime the variable capacitor that effectively multiplies the priming energy of the power source by extracting energy from the passing vehicle. Alternately priming the variable capacitor using charge from the power source and discharging it at a later time in a cyclic manner to change the capacitance produce a significantly large amount of electrical energy is produced due to change in capacitance.

The various methods of harnessing this wind energy, theoretical calculations and flow simulation are performed. The detailed literature and results for this idea are also generated in the enclosure.

MAGISTRO DARBO UŽDUOTIS

TEMA:

Natūralaus atsinaujinančio energijos šaltinio, kurį naudojant būtų galima gaminti elektrą, identifikavimas. Išsenkantys tradiciniai energijos šaltiniai ir jų aplinkai sukeliama žala veda prie naujų idėjų - kaip įveikti tokių šaltinių trūkumą netolimoje ir tolimoje ateityje bei kaip rasti nesibaigiančių energijos šaltinių, kurie galės pakeisti tradicinius, kai jie bus visiškai išnaudoti. Šio magistro darbo tikslas yra identifikuoti tokius atsinaujinančios ir nekenksmingos aplinkai energijos šaltinius ir pritaikyti tinkamus metodus, kaip juos panaudoti elektros gamybai.

TIKSLAI:

- Identifikuoti natūralią, atsinaujinančią ir nekenkiančią aplinkai energiją.
- Suskaičiuoti energijos matavimo vienetų ir laiko santykį, kad energija būtų išmintingai ir saugiai panaudota.
- Ištirti galimybes ir vietas, kur energija gali būti išgaunama.
- Suskaičiuoti įvairius įvesties parametrus saugumo sumetimais.
- Atlikti teorinius skaičiavimus ir virtualius srauto modeliavimus su pagrindine informacija.
- Palyginti įvairius energijos naudojimo modelius tam tinkamoje aplinkoje.
- Įvertinti galimai išgaunamą energiją.
- Pateikti lentelėje ir palyginti rezultatus.

SANTRAUKA

Šio darbo tikslas yra paaiškinti novatorišką metodą, kaip gaminti natūralią energiją iš greitai ir įvairiomis kryptimis judančios transporto priemonės (traukinio). Šiuo metodu gaunama energija yra žmogaus veiklos pasekmė. Energijos gamybai naudojami metodai yra vėjas ir traukinio judėjimas. Viena didžiausių kliūčių plačiam vėjo energijos vartojimui yra ta, kad dauguma teritorijų nėra labai vėjuotos. Ši alternatyvi traukinių gaminama vėjo energijos forma yra labai unikali, nes nepriklauso nuo jokio natūralaus energijos šaltinio. Judantis traukinys slegia orą priekyje ir stumia jį į šonus, tokiu būdu, traukiniui judant į priekį, sukurdamas vakuumą gale ir šonuose. Tada oro gūsis trenkiasi į galą ir šonus, kad užpildytų šį vakuumą. Vėjo judėjimo sukurta kinetinė energija yra panaudojama elektros gamybai. Taip išgauta elektros energija gali būti toliau naudojama įvairiais tikslais.

Tikslas yra išgauti elektros energiją, naudojant vėjo turbiną, sukamą dėl traukinio judėjimo, ir elektros energijos generavimo sistemą. Bet kas gyvenantis netoliese geležinkelio bėgių gali patvirtinti, kad greitai pralekiantis traukinys sukelia pakankamai stiprų vėją. Galvojama sukurti vėjo turbiną, kuri gali būti įtaisyta šalia bėgių, kur važiuoja traukinys. Vėjas verstų turbiną gaminti energiją. Šie prietaisai galėtų būti įtaisyti prie geležinkelio ar metro bėgių ir gamintų energiją iš niekur kitur nenaudojamų šaltinių. Elektros energijos generavimo sistema susideda iš kintamojo kondensatoriaus ir energijos šaltinio. Energijos šaltinis naudojamas kaip generatorius, priverčiantis veikti kintamąjį kondensatorių, kuris efektyviai padidina iš šaltinio gaunamos energijos kiekį, papildydamas jį energija, gauta iš pravažiuojančio traukinio. Pakaitomis verčiant dirbti kintamąjį kondensatorių – tam tikrais ciklais įjungiant elektros šaltinio energiją ir vėliau ją išjungiant, kad būtų keičiama talpa – yra išgaunama daug daugiau elektros energijos.

Įvairūs šios vėjo energijos panaudojimo metodai, teoriniai skaičiavimai ir srauto modeliavimas yra aprašyti darbe. Prieduose taip pat yra pateikta literatūra bei šios naujos idėjos rezultatai.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1:

INTRODUCTION

All human activities require energy, food to sustain and enable our mobility, gasoline for our automobiles and transportation, electricity for our lights, heating and air conditioning. Sources and quantum of fossil energy are dwindling day by day and getting exhausted at a very fast rate. Hence conservation, tapping new sources of energy and harnessing of the same from the various non-conventional sources, is an important aspect of energy production/ conservation and utilization all over the world. Renewable energy from wind and solar is sustainable and does not lead to increase carbon dioxide emissions. The idea of a train and being able to utilize its very infrastructure to generate electricity is very fascinating. Generating power by harnessing the wind energy created by fast moving trains is a new idea.

This process does not involve any sophisticated mechanism and ensures complete safety. This method of power production paves way to less diligence and can be produced in the place where we reside. The hunger for alternative forms of energy continues and therefore we have generated hope.

The renewable energy is considered as a new technology and an alternating energy source to be used instead of fossil fuel, its continuous rising cost of it and due to growing concern to reduce the effects of climate change, such as global warming, generated by extensive and deliberate use of fossil fuels, mainly in the electric power generating plants and transport. Global warming will continue unless dependence on fossil is reduced, thus the Wind power has a key role in reducing greenhouse gas emissions.

1.1 CONVENTIONAL AND NON- CONVENTIONAL ENERGY SOURCES:

1.1.1 CONVENTIONAL: Energy that has been used from ancient times is known as conventional energy. Coal, natural gas, oil, and firewood are examples of conventional energy sources. (Or usual) sources of energy (electricity) are coal, oil, wood, peat, and uranium.

1.1.2 NON CONVENTIONAL: The contemporary non-conventional sources of energy like wind, tidal, solar etc., were the conventional sources until James Watt invented the steam engine in the eighteenth century. In fact, man using wind-powered ships only explored the New World. The non-conventional sources are available free of cost, are pollution-free and inexhaustible. Man has used these sources for many centuries in propelling ships, driving windmills for grinding corn and pumping water, etc. Because of the poor technologies then existing, the cost of harnessing energy from these sources was quite high. Also because of uncertainty of period of availability and the difficulty of transporting this form of energy, to the place of its use are some of the factors that came in the way of its adoption or development. The use of fossil fuels and nuclear energy replaced totally the non-conventional methods because of inherent advantages of transportation and certainty of availability; however these have polluted the atmosphere to a great extent. In fact, it is feared that nuclear energy may prove to be quite hazardous in case it is not properly controlled.

1.1.3 COMPARISON BETWEEN CONVENTIONAL AND NON-CONVENTIONAL ENERGY SOURCES:

1. **EXAMPLES:**

   Conventional energy, such as thermal powers (from coal, petroleum, and natural gas), hydel power (from high velocity of running water) are tapped and used abundantly at present. Their uses are practiced for a long time.

   Non-conventional sources of energy (solar energy, tidal energy, geo-thermal energy, wind energy, etc.) are not used frequently and in large scale (commercially). Their uses are comparatively more recent.

2. **AVAILABILITY:**

   Conventional energies are non-renewable in nature. The enormous reserve of fossil fuels (coal, crude-oil, natural gas, etc.) is fast depleting.

   Non- conventional energies are flow-resources. There is no anxiety for their exhaustion.

3. **ENVIRONMENT:**

   Conventional energy produces air pollution and causes environmental threats. The generation of **non-conventional energy** does not produce air pollution.

4. **COST:**

   Conventional energy sources though most common in use, are relatively expensive.

   Non-conventional energy is much cheaper, the adoption of these methods involves only in one time investment on equipment and very low maintenance cost.

It is a most pronounced fact that all the conventional sources are getting rare, endangered and extinct, they are non environmental friendly methods as they produce high levels of carbon dioxide and other greenhouse gasses that add to the increased greenhouse effect an in the atmosphere and global warming (uranium leaves different dangerous byproducts).

We similarly expect that all the non-conventional sources will replace the conventional ones. They will be more familiar in every day life as they are all free, green and emit no carbon dioxide (well, biomass does, but it prevents the production of methane which is a greenhouse gas 21 times more dangerous that CO2).

CHAPTER 2:

WIND ENERGY

The origin for Wind Energy is Sun. When sun’s rays falls on the earth, it’s surface gets heated up and as a consequence unevenly winds are formed. Kinetic energy in the wind can be used to run wind turbines but the output power depends upon the wind speed. Turbines generally require a wind in the range of 20km/hr. In practice relatively few land areas have significantly prevailing winds. Otherwise wind power is one of the most cost competitive renewable energy today and this has been the most rapidly growing means for electricity generation at the turn of 21st century and provides a complement to a large-scale base load power stations. Its long-term technical potential is believed to be 5 times current global energy consumption or 40 times current electricity demand.[1]

2.1 WIND TURBINE:

A **wind turbine** is a device that converts kinetic energy from the wind into electrical power. The term appears to have migrated from parallel hydroelectric technology (rotary propeller). The technical description for this type of machine is an **aerofoil-powered generator**

2.2 SIGNIFICANCE:

Wind turbines are good media for generating electricity from a clean and renewable resource for our homes and businesses. It comes with a couple of advantages for both humans and the environment, namely the following:

- Wind turbines can harness a plentiful energy source, wind.
- The use of electricity generated in this method can cut our carbon footprint (the total amount of greenhouse gases used to support human activity) because it doesn't release any harmful gases or pollutants in the process of generating electricity.
- The use of wind energy can cut our electricity bills since wind is a free source of energy, and thus, after the payment for the initial installation, electricity costs will be reduced.
- The energy converted can be stored. If our houses are not connected to the National Power Grid, we can store the excess electricity produced from the wind turbine in batteries and use it when there is no wind.
- Trading of electricity back to the grid, meaning if our wind system is producing more than what we need, someone else can use it, and thus, we can sell it.

2.3 DEFINITION OF WIND TURBINES:

Wind turbines are machines that generate electricity from the kinetic energy of the wind. In history, they were more frequently used as a mechanical device that turned machinery. Today, turbines can be used to generate large amounts of electrical energy in wind farms both onshore and offshore.

There are two kinds of wind turbine, namely the Horizontal Axis Wind Turbine (HAWT) and the Vertical Axis Wind Turbine (VAWT). Though many VAWTs are used nowadays to produce electricity, the HAWT still remains more practical and popular than the VAWT and is assumed as the focus of most wind turbine discussions.[1]

2.4 HORIZONTAL AXIS WIND TURBINES

Fig 2.1: Horizontal Axis Wind Turbine

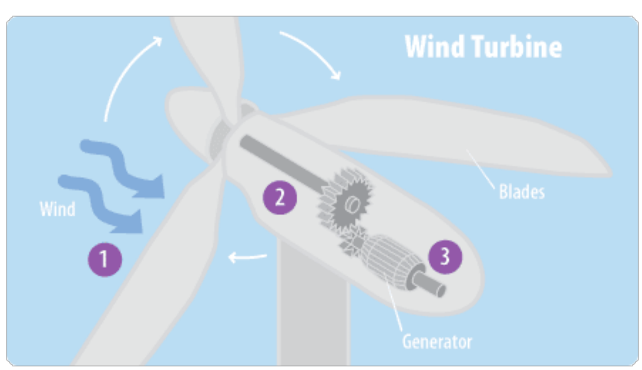


Fig 2.2: Working Principle of HAWT.

The horizontal wind turbine is a turbine in which the axis of the rotor's rotation is parallel to the wind stream and the ground. Most HAWTs today are two or three-bladed, though some may have fewer or more blades. There are two kinds of Horizontal Axis Wind Turbines: the upwind wind turbine and the downwind wind turbine.

The HAWT works when the wind passes over both surfaces of the airfoil shaped blade but passes more rapidly at the upper side of the blade, thus, creating a lower-pressure area above the airfoil. The difference in the pressures of the top and bottom surfaces results in an aerodynamic lift. The blades of the wind turbine are constrained to move in a plane with a hub at its center, thus, the lift force causes rotation about the hub. In addition to the lifting force, the drag force, which is perpendicular to the lift force, impedes rotor rotation.

2.4.1 TYPES OF WIND TURBINES:

UPWIND WIND TURBINES:

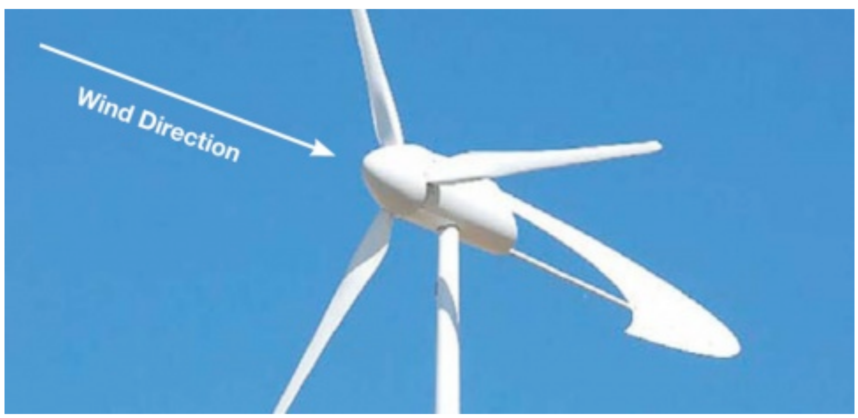


Fig 2.3: Up wind -Wind Turbine

The upwind turbine is a type of turbine in which the rotor faces the wind. A vast majority of wind turbines have this design. Its basic advantage is that it avoids the wind shade behind the tower. On the other hand, its basic drawback is that the rotor needs to be rather inflexible, and placed at some distance from the tower. In addition, this kind of HAWT also needs a yaw mechanism to keep the rotor facing the wind.

DOWNWIND WIND TURBINES:

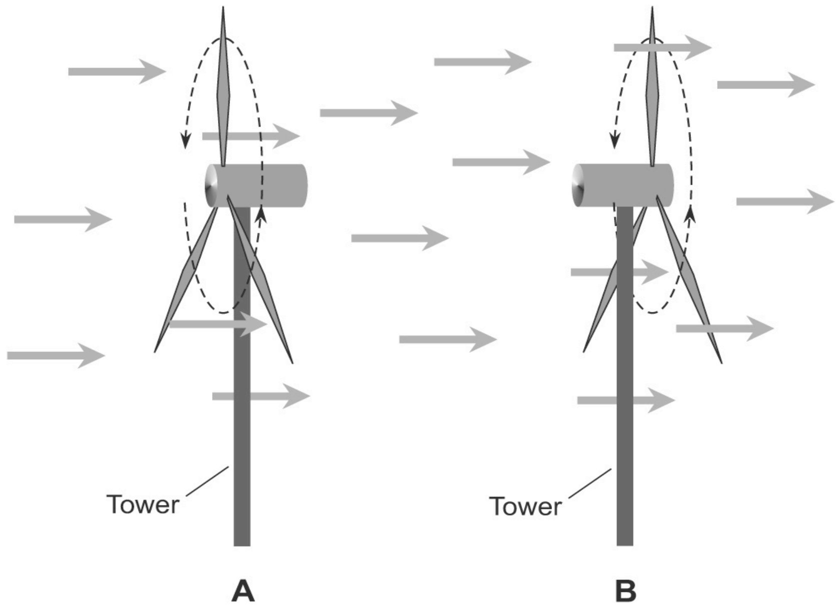


Fig 2.4: Down Wind- Wind Turbine

The downwind turbine is a turbine in which the rotor is on the downwind side (lee side) of the tower. It has the theoretical advantage that they maybe built without a yaw mechanism, considering that their rotors and nacelles have the suitable design that makes the nacelle follows the wind passively. Another advantage is that the rotor may be made more flexible. Its basic drawback, on the other hand, is the fluctuation in the wind power due to the rotor passing through the wind shade of the tower.

2.4.2 ADVANTAGES AND DISADVANTAGES:

The advantages of the HAWT over the VAWT are:

- Blades are to the side of the turbine's center of gravity, helping stability.
- The turbine collects the maximum amount of wind energy by allowing the angle of attack to be remotely adjusted.
- The ability to pitch the rotor blades in a storm so that damage is minimized.
- The tall tower allows the access to stronger wind in sites with wind shear and placement on uneven land or in offshore locations.
- Most HAWTs are self-starting.

- Can be cheaper because of higher production volume On the other hand, the disadvantages of the HAWT compared to the VAWT is that:
- It has difficulties operating near the ground
- The tall towers and long blades are hard to transport from one place to another and they need a special installation procedure
- They can cause a navigation problem when placed offshore

2.5 VERTICAL AXIS WIND TURBINES

2.5.1 DEFINITION:

The vertical axis wind turbine is an old technology, dating back to almost 4,000 years ago. Unlike the HAWT, the rotor of the VAWT rotates vertically around its axis instead of horizontally. Though it is not as efficient as a HAWT, it does offer benefits in low wind situations wherein HAWTs have a hard time operating. It tends to be easier and safer to build, and it can be mounted close to the ground and handle turbulence better than the HAWT. Because its maximum efficiency is only 30%,it is only usually just for private use.

2.5.2 TYPES:

DARRIEUS TURBINE:

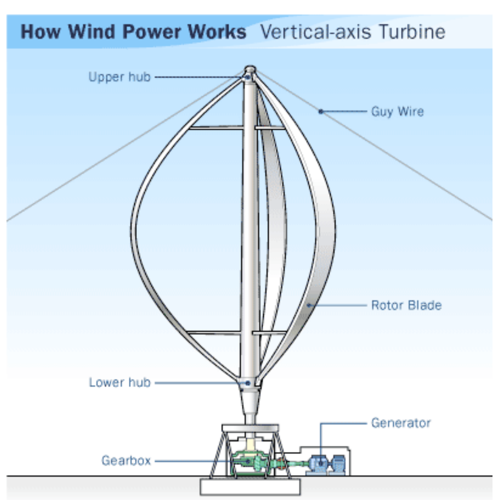


Fig 2.5: Working of Darrieus Turbine

The Darrieus turbine is composed of a vertical rotor and several vertically oriented blades. A small powered motor is required to start its rotation, since it is not self-starting. When it already has enough speed, the wind passing through the airfoils generate torque and thus, the rotor is driven around by the wind. The lift forces produced by the airfoils then power the Darrieus turbine. The blades allow the turbine to reach speeds that are higher than the actual speed of the wind, thus, this makes them well suited to electricity generation when there is a turbulent wind.

GIROMILL TURBINE:

Fig 2.6: Giromill Turbine

The Giromill Turbine is a special type of Darrieus Wind Turbine. It uses the same principle as the Darrieus Wind Turbine to capture energy, but it uses 2-3 straight blades individually attached to the vertical axis instead of curved blades. It is also applicable to use helical blades attached around the vertical axis to minimize the pulsating torque.

SAVONIUS TURBINES:

Fig 2.7: Savonius Turbine Representation

The Savonius wind turbine is one of the simplest turbines. It is a drag-type device that consists of two to three scoops. Because the scoop is curved, the drag when it is moving with the wind is more than when it is moving against the wind. This differential drag is now what causes the Savonius turbine to spin. Because they are drag-type devices, this kind of turbine extracts much less than the wind power extracted by the previous types of turbine.

2.5.3 ADVANTAGES AND DISADVANTAGES:

Just like the HAWT, the VAWT also comes with a handful of advantages over the HAWT, namely:

- Since VAWT components are placed nearer to the ground, it has an easier access to maintenance
- Smaller cost of production, installation, and transport
- Turbine does not need to be pointed towards the wind in order to be effective
- VAWTs are suitable in places like hilltops, ridgelines and passes
- Blades spin at a lower velocity, thus, lessening the chances of bird injury
- Suitable for areas with extreme weather conditions like mountains The disadvantages of the VAWT, on the other hand are:
- Most of them are only half as efficient as HAWTs due to the dragging force

- Air flow near the ground and other objects can create a turbulent flow, introducing issues of vibration
- VAWTs may need guy wires to hold it up (guy wires are impractical and heavy in farm areas)

2.6 ENERGY REQUIREMENTS:

World primary energy demand grows by 1.6% per year on an average between 2006 and 2030 - an increase of 45%. Demand for oil rises from 85 million barrels per day now to 106 mb/d in 2030 - 10 mb/d less than projected last year. Modern renewable energies grow most rapidly, overtaking gas to become the second-largest source of electricity soon after 2010.With increasing environmental concern, and approaching limits to fossil fuel consumption, wind power has regained interest as a renewable energy source. This new generation of windmills produces electric power and is more generally used for all applications, which requires power.

2.7 OBJECTS OF THE INNOVATION:

The main object of the innovation is to provide a method and a system for generating electricity using the consequences of human activity. Easily available wind induced by moving train in transit or in operation. The other object of the invention is to provide a method and a system for generating electricity by using high wind pressure generated by moving vehicles, using this free renewable input namely air and independent of the vagaries of seasonal winds having the variation in direction and wind speeds when they do flow and that too neither at all times or places nor having the necessary force of wind to operate wind mill to generate electricity as required.

CHAPTER 3:

FIELD OF INVENTION

3.1 BACKGROUND:

The fixed wind powered electricity generation systems in use, till now are dependent on wind direction and the force of the wind. But the wind is not available at all places and all time through out the year. Therefore, there exists an immense need of a system for generating electricity from wind induced by moving vehicles, trains or airplanes, which is available through out the year at various places and with sufficient force of wind. Therefore this invention provides a solution to the problem for generating electricity in this manner.[2]

3.2 METHOD:

This invention relates to a method for generating electricity using high wind pressure generated by fast moving vehicles channeling the induced wind in the direction of the wind turbine. A fast moving vehicle compresses the air in the front of it and pushes the air from its sides thereby creating a vacuum at its rear and its sides as it moves forward.

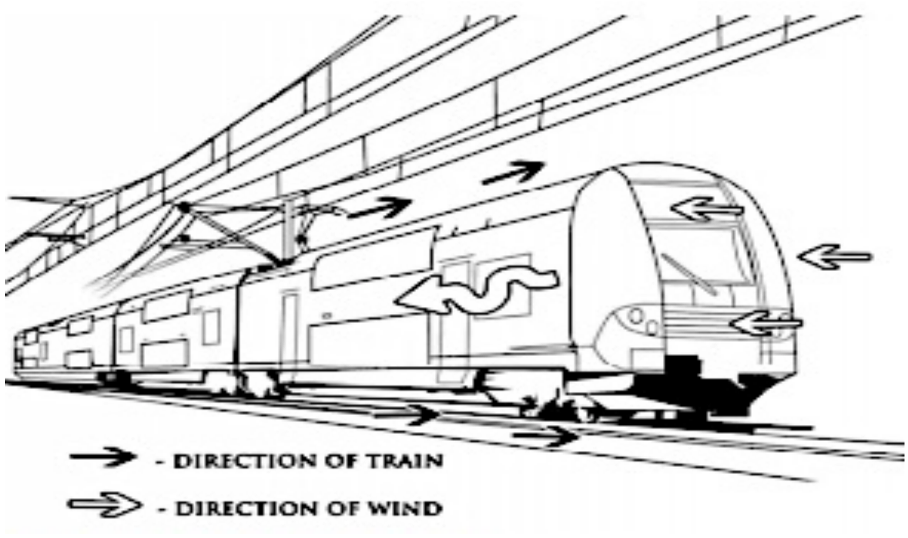
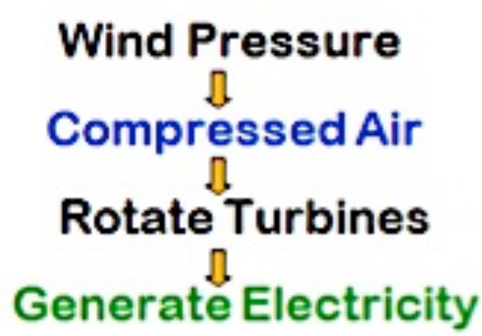


Fig 3.1: Direction of Wind Flow

The kinetic energy of the wind movement thus created can be used to generate electricity. The moving vehicles encounters wind may be railway trains or airplanes, will sweep off it, in a faster manner making heavy winds. During this, when a wind turbine, if fit to the moving vehicle will generate adequate amount of energy. The airflow will cause turbine to rotate and thus electricity can be produced.

3.3 DESCRIPTION OF INVENTION:



A. Capturing wind induced by moving vehicles:

The moving vehicles may be all types of light or heavy vehicles running on road, such as two, three, four wheelers or even bigger vehicles. The moving vehicles could be trains running on railway track. The vehicles could also be aircraft moving on to the runway, taking off or landing; when testing the propellers in the workshops, proceeding to or standing bye in the holding area before taking off. These induces fast winds in all it direction of propagation.[1]

Lets consider the energy that we can generate by harnessing the wind energy obtained beside the railway tracks due the trains moving at relatively high speed and also at constant speed which makes it easier for us to experiment and approximate the energy we could generate in this respect.

B. Routing the induced wind in the direction of the wind turbine:

If the wind is properly directed towards the wind turbine blades, optimum electricity may be generated. The desired direction of wind is obtained by a means for channeling wind, in the direction of the wind turbine. Channeling of wind in a desired direction may be obtained by, at least one truncated cone or pyramid shaped housing or a pair of planar members converging towards the blades of the wind turbine. Aerodynamics is the science and study of the physical laws of the behavior of objects in an air flow and the forces that are produced by air flows. The shape of the aerodynamic profile is decisive for blade performance. Even minor alterations in the shape of the profile can greatly alter the power curve and noise level. Therefore a blade designer does not merely sit down and outline the shape when designing a new blade.

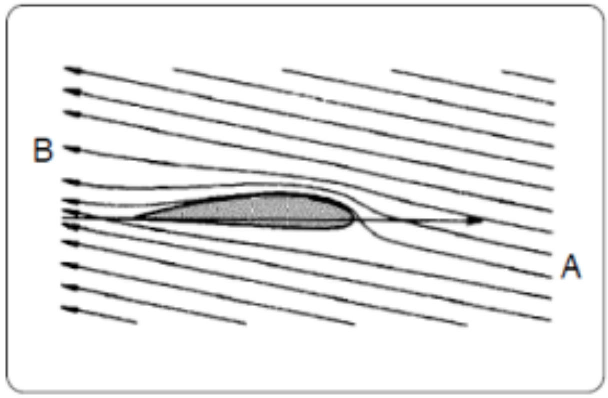


Fig 3.2: Aerodynamics of Wind Along the Blade

The aerodynamic profile is formed with a rear side, is much more curved than the front side facing the wind. Two portions of air molecules side by side in the air flow moving towards the profile at point A will separate and pass around the profile and will once again be side by side at point B after passing the profiles trailing edge. As the rear side is more curved than the front side on a wind turbine blade, this means that the air flowing over the rear side has to travel a longer distance from point A to B than the air flowing over the front side. Therefore this air flow over the rear side must have a higher velocity if these two different portions of air shall be reunited at point B. Greater velocity produces a pressure drop on the rear side of the blade, and it is this pressure drop that produces the lift. The highest speed is obtained at the rounded front edge of the blade. The blade is almost sucked forward by the pressure drop resulting from this greater front edge speed. There is also a contribution resulting from a small over-pressure on the front side of the blade. Compared to an idling blade the aerodynamic forces on the blade under operational conditions are very large. Most wind turbine owners have surely noticed these forces during a start-up in good wind conditions. The wind turbine will start to rotate very slowly at first, but as it gathers speed it begins to accelerate faster and faster. The change from slow to fast acceleration is a sign that the blades aerodynamic shape comes into play, and that the lift greatly increases when the blade meets the head wind of its own movement. The fast acceleration, near the wind turbines operational rotational speed, places great demands on the electrical cut-in system that must capture and engage the wind turbine without releasing excessive peak electrical loads to the grid. The desired direction may be transverse or parallel to the direction of plane of rotation of blades depending upon the type of wind turbine used or the direction of wind, or it the design of the wind turbines. The turbines are connected to electricity generator to generate electricity. The generated electricity may be used directly or stored in batteries, which can be used at the time of need.

C. Converting the energy of the wind into mechanical energy by using wind turbine

There are two primary physical principles by which energy can be extracted from the wind. These are through the creation of either lift or drag force (or through a combination of the two). Drag forces provide the most obvious means of propulsion, these being the forces felt by a person (or object) exposed to the wind. Lift forces are the most efficient means of propulsion but being subtler than drag forces are not so well understood. Lift is primary due to the physical phenomena known as Bernoulli's Law. This physical law states that when the speed of airflow over a surface is increased the pressure will then drop. This law is counter to what most people experience from walking or cycling in a head wind, where normally one feels that the pressure increases when the wind also increases. This is also true when one sees an airflow blowing directly against a surface, but it is not the case when air is flowing over a surface. One can easily convince oneself that this is so by making a small experiment.[3]

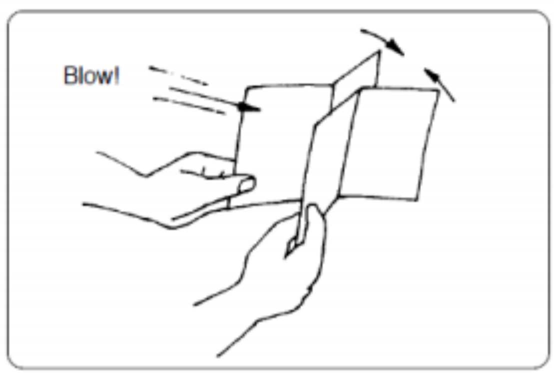


Fig 3.3: Bernoulli's Law

Take two small pieces of paper and bend them slightly in the middle. Then hold them as shown in the diagram and blow in between them. The speed of the air is higher in between these two pieces of paper than outside (where of course the air speed is about zero), so therefore the pressure inside is lower and according to Bernoulli's Law the papers will be sucked in towards each other. One would expect that they would be blown away from each other, but in reality the opposite occurs. This is an interesting little experiment that clearly demonstrates a physical phenomenon that has a completely different result than what one would expect.

D. Converting that mechanical energy into electrical energy by using a generating device:

The generator is the unit of the wind turbine that transforms mechanical energy into electrical energy. The blades transfer the kinetic energy from the wind into rotational energy in the transmission system, and the generator is the next step in the supply of energy from the wind turbine to the electrical grid. The wind turbine may be connected to an electricity generator. The generated electricity may to be stored in pluralities of batteries from which energy may be used as per the need. These turbines have been designed to power small units like compartments of train, recharging batteries, although we should mention that it is also quite easy to imagine how a specially designed wind turbine like this could sit on top of the train or at front and power its engine as you cruise along on the rail/road. This wind turbine was developed to be used as an alternative means to recharge communications equipment too.[6]

CHAPTER 4:

AIR FLOW INDUCED BY MOVING TRAINS

In addition to the pressure variations created by the in viscid flow field, there is a viscous effect where the train drags along air, producing a boundary layer that grows outward down the length of the train. The effect of this phenomenon, along with the wake created behind the train, induces an airflow to the surroundings that can be best described as follows: "…viscous flow effect … involves the action of the train boundary layer which grows in width down the length of the train and in which, the velocity is varying continuously from train speed in the region immediately adjacent to the train down to a very small virtually zero velocity at its outside edge. The effect of the boundary layer is that of a drought moving along the track side parallel to the train, and imparting a force on an object situated in it due to the consequent pressure field set up around it. "Behind it, the train leaves a turbulent wake which, due to its mixing with the surrounding air, rapidly spreads out behind, and in so doing dissipates its energy. The effect of this at the track side is to cause a buffeting which is at a maximum just after the train passes and then reduces in strength as the train proceeds on its way. As the wake consists of a complex vortex field where the flow is highly turbulent and circulatory in motion, an object enveloped in the wake may be subjected to violent force changes that could act in virtually any direction. It is generally felt that the wake produces effects which are the most destabilizing to track side objects." People or objects situated close to a train passing at high speeds can experience these high airflow forces. In addition, the wake induces airflow at the rear of the train that can stir up debris around the track that, in turn, can be propelled toward people on station platforms. Induced airflow speeds have been obtained from both theoretical computation and from test measurements.[4]

CHAPTER 5:

INVESTIGATION OF THE PARAMETERS OF HARNESSING WIND ENERGY BY ARRANGEMENT OF WIND TURBINES BESIDE THE RAILWAY TRACKS

5.1 PROPOSED MODEL NUMBER 1:

5.1.1 *THE ARCHIMEDES WINDTURBINE*

LITERATURE REVIEW FOR ARCHIMEDES WINDTURBINE:

The first thing people ask me is how? How does it work, followed by how did you get it done? So, let us first explain **WHAT** the Archimedes Rotor in fact is. A wind turbine consists of several parts. A rotor, which converts the straightforward movement of the wind into a rotary movement, a yawing mechanism that aims the rotor in its most favorable position, the generator which converts the kinetic energy into electricity and a number of safety systems. Altogether, a number of disciplines are called upon to come to a working product. In this paper I will address to each of the subjects separately. The greatest innovation concerns the shape of the rotor. Therefore we will elaborate on this most extensively.[9]

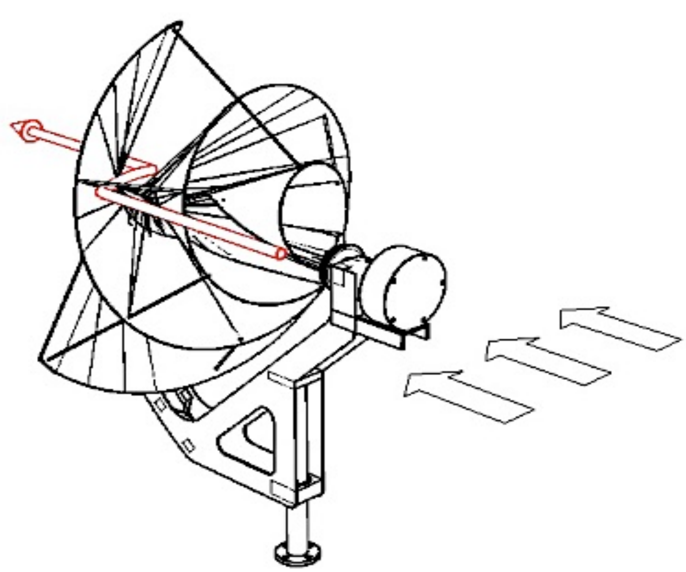


Fig 5.1: Archimedes Turbine

Design of the Archimedes Spiral Wind Turbine:

Figure shows a schematic diagram of a 0.5 kW class Archimedes spiral wind turbine. The three blades were connected to each other with 120°and each blade has a symmetric arrangement around the shaft and its shape was similar to a triangular pyramid. The outer diameter of the 0.5 kW class Archimedes wind turbine was 1.5 m. The aerodynamic equation for torque prediction with regard to the angular velocity was estimated using the following four assumptions:

- In-compressible and steady flow;
- The fluid moves to the control volume parallel to the rotating axis;
- The quantities of mass flow at the three outlet boundaries were the same as each other;
- Relative outlet velocity was constant in outlet boundary and the direction of the velocity was parallel to the tangential direction at the blade edge.

To provide the torque and power of the small wind turbine with a spiral wind blade, the momentum equation for the control volume employed in this study can be defined using Equation (1):

$$\frac{\partial}{\partial t}\int_{CV}(r\times V)\rho d\forall+\int_{CS}(r\times V)\rho V\cdot\hat{n}dA=\sum(r\times F)$$

Equation (1) is the angular momentum equation based on the control volume. From the steady state assumption, the first term in Equation (1) becomes zero because of the time independence, and Equation (1) can be simplified as Equation (2):

$$\int_{CV}(r\times V)\rho dV\cdot\hat{n}dA=\sum(r\times F)$$

The continuity equation on a fixed control volume is represented by Equation (3):

$$\frac{\partial}{\partial t}\int_{CV}\rho dV+\int_{CV}\rho W\cdot\hat{n}dA=0$$

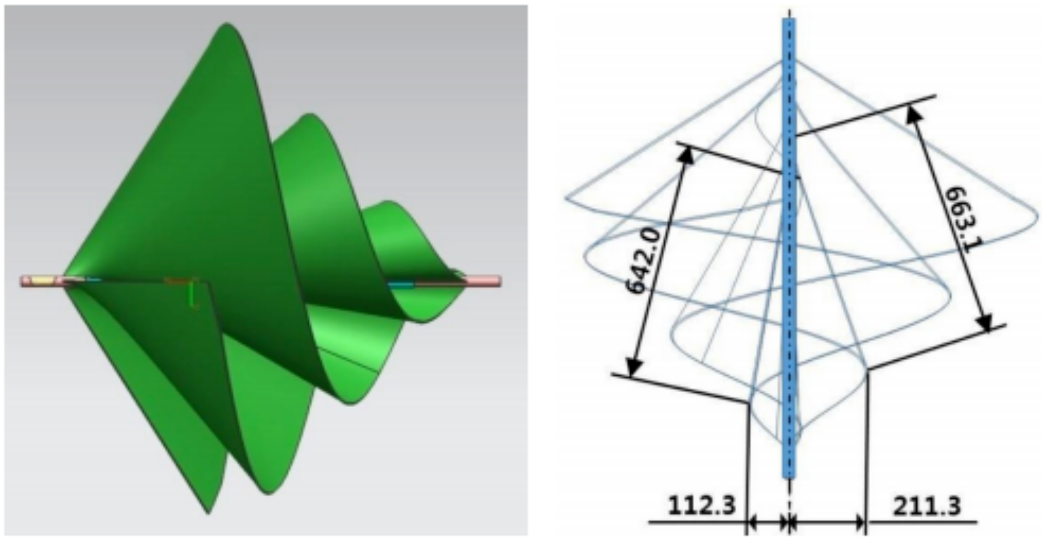
From the steady state assumption, the first term in Equation (3) becomes zero because of the constant density. In addition, the second term means the sum of the quantities of mass flow that pass through the control volume. Equation (3) can be simplified to Equation (4):

$$-\dot{m}_{in}+\dot{m}_{out}=0$$

Schematic diagram of the Archimedes spiral wind turbine blade:

(a) Side-view of the Archimedes spiral wind turbine blade;

(b) Geometry of a 0.5 kW Archimedes wind turbine blade.



(a) (b)

Fig 5.2: Schematic diagram of the Archimedes spiral wind turbine blade

The shape parameters can be defined for the equation development. The shape parameters include R1, and S1, as shown in figure. First, Teat is defined by the angle between the rotational axis and the tip of the blade, R1 means the vertical distance of the outer blade tip from the rotational axis, R2 means the vertical distance of the inner blade tip from the rotational axis, and S1 means the horizontal distance between the front blade tip and the root of the spiral blade. The mass flow at flow in and flow out is defined by Equations (5) and (6) using pre-defined shape parameters:

$$\dot{m}_{in} = \rho U_{\infty} \sin\gamma \times \pi(\frac{R_1 + R_2}{2})S_1$$

$$\dot{m}_{out} = 3\rho A_{out} W_{\theta}$$

Where "W_θ" means the tangential component for the relative velocity. Additional shape parameters are derived in detail in the Appendix.

Finally, the torque of the blade can be expressed using Equation (7):

$$\therefore T_{shaft} = 3\rho V_{\theta}^2 \times \frac{(R_2 - R_1)}{6L_1(L_2 - L_1)} \times [R_2(2L_2^3 + L_1^3 + L_1 L_2^3) - L_1 R_1 (L_1 + L_2)^2]$$

The power is a multiplication of the torque and angular velocity, and can be expressed using Equation (8):

$$Power = T_{shaft}\omega$$

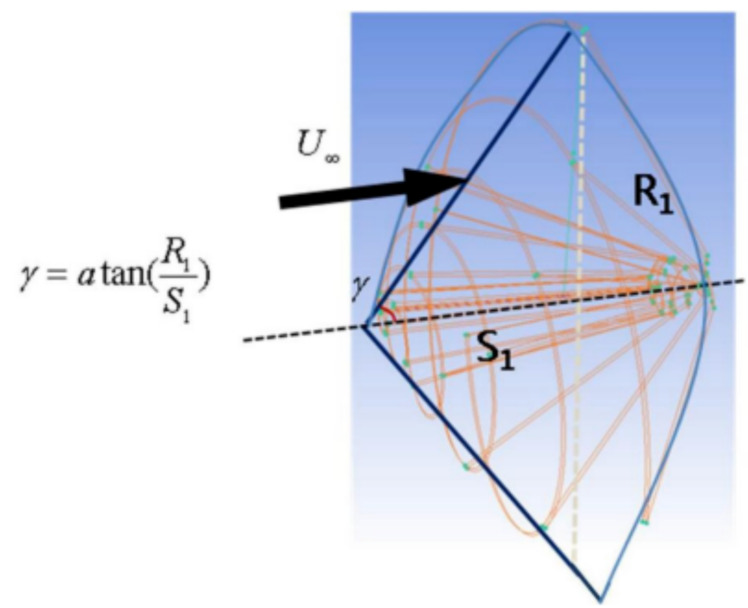


Fig 5.3: Shape parameter of the Archimedes spiral wind turbine blade.

Experimental Setup and Methods of ARCHIMEDES TURBINE:

Figure shows the experimental model of Archimedes spiral wind turbine with 0.5kW placed on atmospheric boundary layer wind tunnel. The open suction type wind tunnel employed in this study has 2m×2m as a cross-sectional area. The experimental model was placed in the center of the wind tunnel. The ball bearings were installed in the frontward and backward of the blade shaft. Wind turbine model employed in this study was consisted with Archimedes spiral wind blade, torque meter, powder brake and rpm sensor. The torque meter was mechanically assembled backward of Archimedes spiral wind blade through main shaft of wind turbine model. For the power coefficient calculation as a function of tip speed ratio, Torque meter, Powder Brake and RPM sensor was employed, respectively.[9]

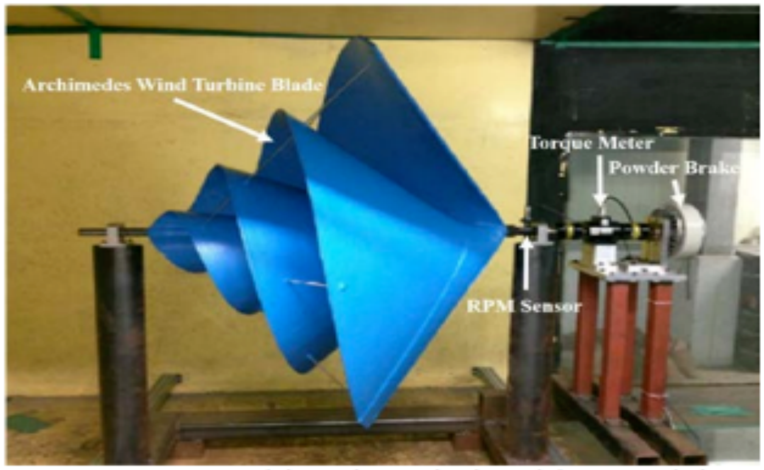


Fig 5.4: Archimedes Wind Turbine Model

The Archimedes Spiral wind blade with 1.5m as a diameter was made of FRP resin and Fiber Glass Sheet through by-layer process. The thickness of the blade was approximately 3 mm in the blade tip region and approximately more than 5 mm in the center region for bonding force with stainless steel shaft, respectively. The rotating force control from powder brake employed in this study can provide an optimal performance of generator. And to calculate the aerodynamic power, torque meter was employed downstream of the blade model. To prevent of the downstream wake flow passing through the frame, the frames of wind turbine model have airfoil shape. In the case of high flow condition, to provide the stability of the spiral wind turbine model, the frame was tied up the wind tunnel with damper for minimizing the vibration between the wind turbine model and wind tunnel. To investigate the approaching wind speed, the Pitot tube was placed 2 m downstream from the wind turbine model, same with the center of the experimental model.

The results and discussions according to the above experiment:

Aerodynamic power production and power coefficient from wind turbine is closely related with the interaction between the rotor and the incoming wind speed. The power coefficient of wind turbine is defined as how efficiently the wind turbine converts the energy from wind into electricity. Tip speed ratio of wind turbine is an essential parameter to how efficient that turbine will perform.

Equation (1) represents the definition on Tip Speed Ratio.

$$\mathrm{TSR} = \frac{\mathrm{R} \times \omega}{U_{in}}$$

Where R[m] is the radius of the wind blade, W[rad/s] is the angular velocity and U_{in}[m/s] is the approaching wind velocity.

The input and output power through the wind energy conversion can be represented as equation (2) and (3), respectively

$$P_{out} = T \times \omega$$

$$P_{in} = \frac{1}{2} \times \rho \times A \times U_{in}^3$$

Where, ρ means the air density, "A" means the cross sectional dimension of wind turbine, U_{in} means the wind speed, T means the torque, W means the angular velocity of wind turbine, respectively. As following to IEC-61400, ρ can be represented as 1.225 kg/m3.

According to the Betz Limit, the theoretical maximum coefficient of power for any wind turbines could not convert more than 59.3% of the kinetic energy of the wind into mechanical energy rotating the wind blade. Good wind turbine generally fall in the 35~45% range of electricity.

In the experiment, the approaching wind speeds were controlled from 3 m/s to 11 m/s with step of 1 m/s. In the case of 3m/s as wind speed, even though the generated power was not so sufficient, the generated maximum aerodynamic power with approximately 13.32 Watt through Archimedes spiral wind blade can be observed at 8.08 as angular velocity.

The rotational power was controlled using powder brake and the maximum aerodynamic power was observed at 16% as PWM (Pulse Width Modulation) control value. In the case of 4m/s as wind speed, the generated the maximum aerodynamic power seems to be approximately 32.03 Watt at 12.26 as angular velocity. In this case, PWM control value had 17% and so up to 11m/s as shown in the below table.

Wind Velocity	Maximum Aerodynamic Power	Maximum Power Coefficient[%]	RPM	Angular Velocity	Tip Speed Ratio
3 m/s	13.32	45.57	77.15	8.08	2.02
4 m/s	32.03	46.24	117.09	12.26	2.30
5 m/s	60.27	44.55	118.84	12.44	1.87
6 m/s	102.58	43.88	194.27	20.34	2.54
7 m/s	168.96	45.51	190.55	19.96	2.14
8 m/s	250.31	45.17	255.98	26.81	2.51
9 m/s	339.10	42.98	217.26	22.75	1.90
10 m/s	544.16	50.27	298.27	31.23	2.34
11 m/s	737.22	51.17	284.27	29.77	2.03

Table 1: Results for the experiment.

5.1.2 Considering the above experiment, a design for the wind turbine to generate electricity beside the railway track has been made as follows:

1. Design:

The proposed model was designed in a virtual space using the software: "SolidWorks". The various views of the model is pictured and depicted below:

Blade:

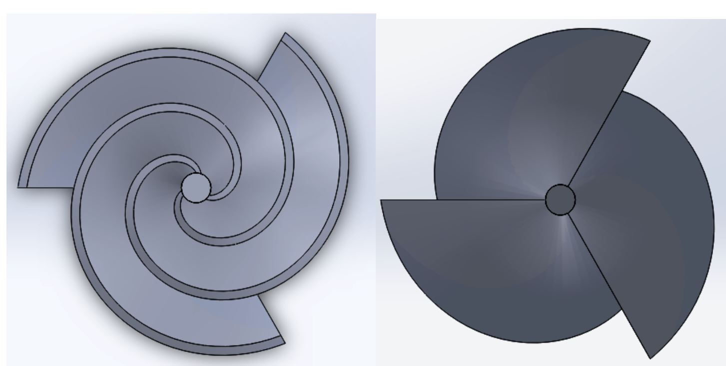


Fig 5.5: Front and Rear Views of the blade design.

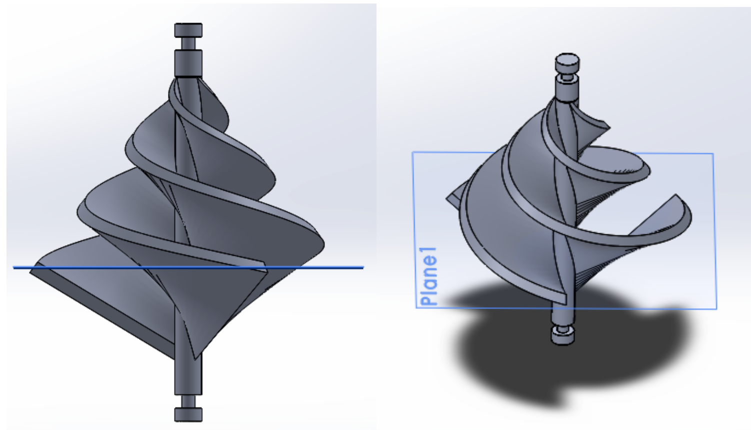


Fig 5.6: Front view of the Blade design.

<u>Mounting Frame Structure:</u>

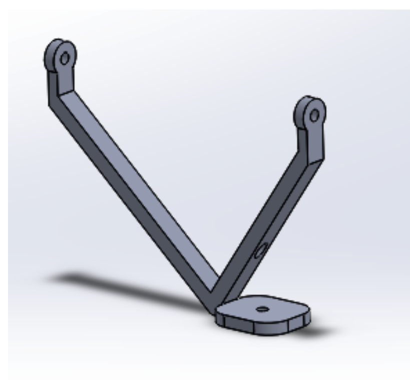


Fig 5.7: Mounting frame for the Blade

<u>Assembly:</u>

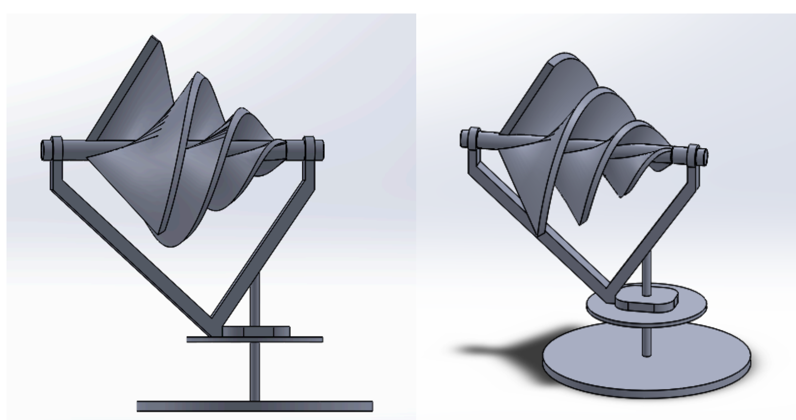


Fig 5.8: Assembly of the proposed design

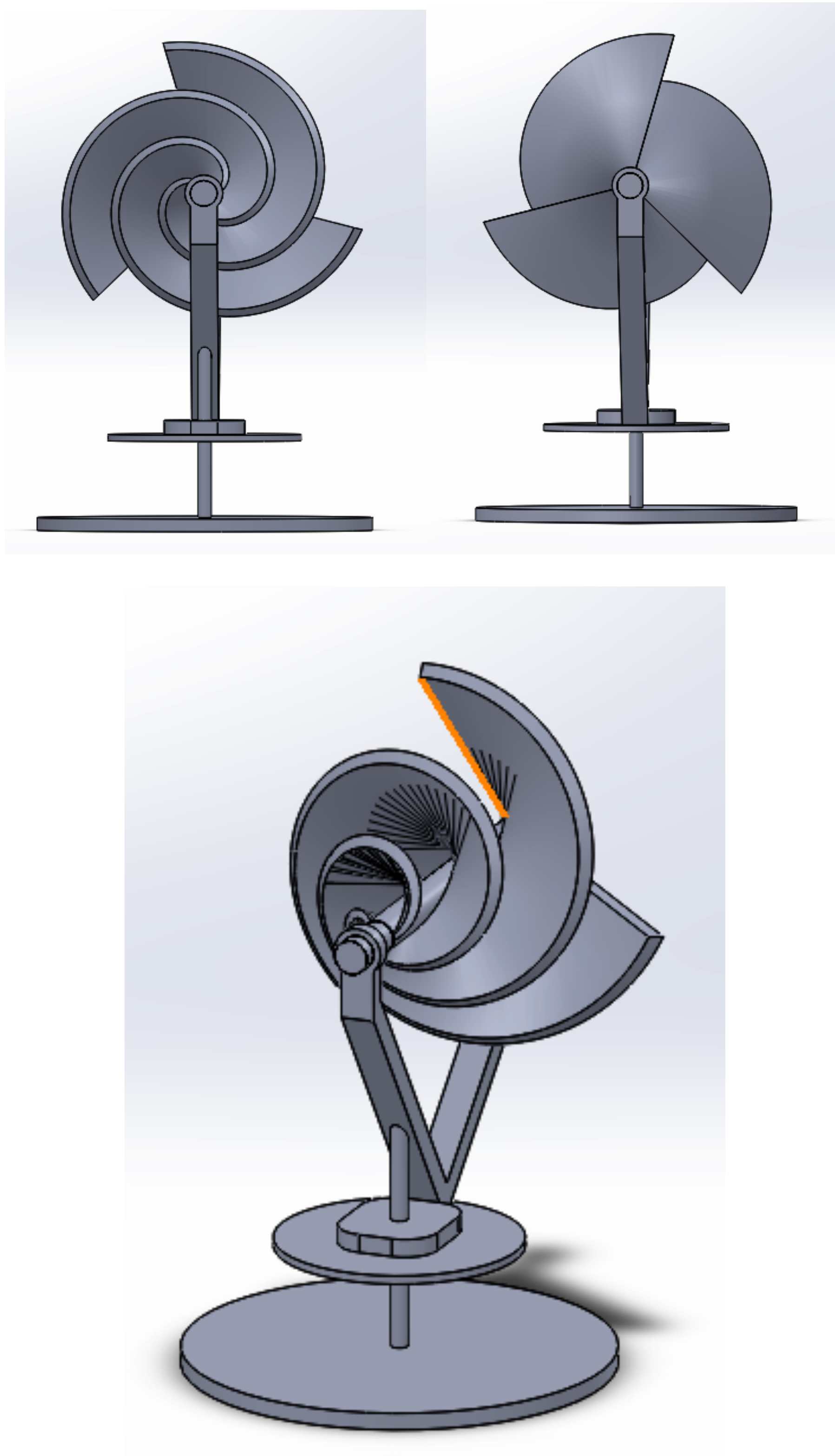


Fig 5.9: Assembly views from different angles

2. Flow simulations and its procedure:

To conduct the flow simulation, it is required to place the assembly inside a wind tunnel. Hence a wind tunnel with lids has to be made and the assembly should be positioned into the wind tunnel in a suitable position.

Wind turbine inside the wind tunnel:

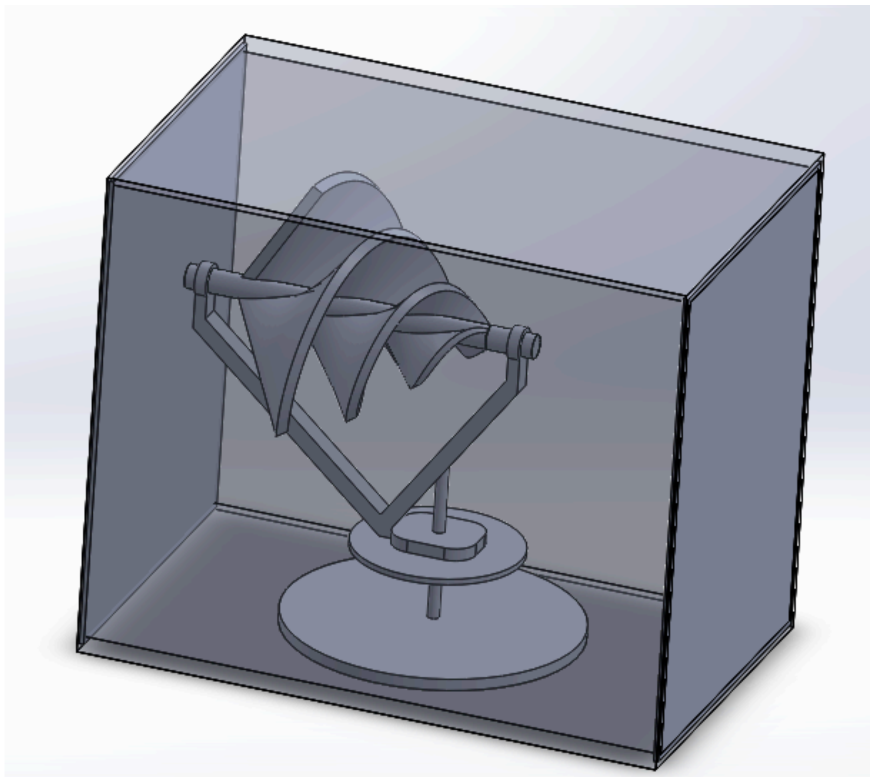
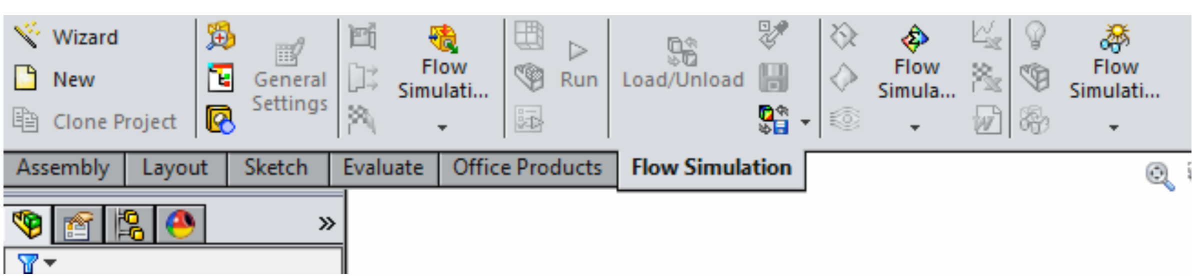


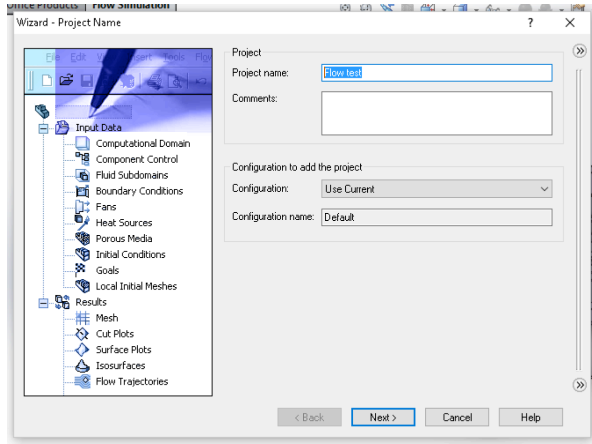
Fig 5.10: Wind tunnel representation

Procedure:

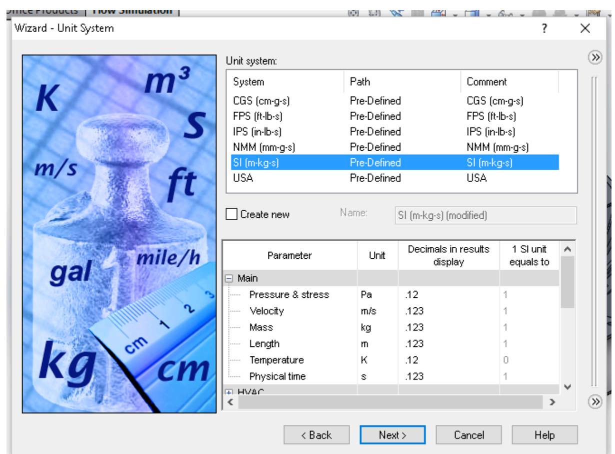
1. Click on “Flow Simulation” add ins, then click “Wizard”



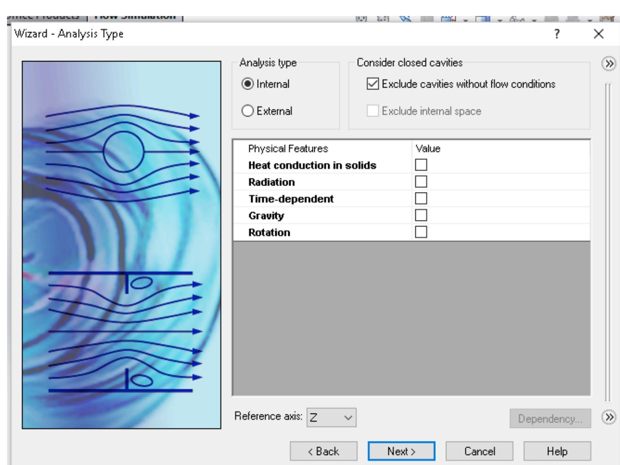
2. Type in a name for the flow simulation data to be stored under a heading and click on “Next”



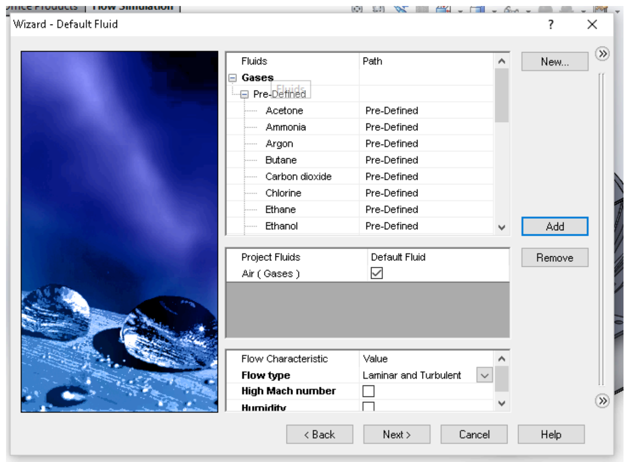
3. Click on “SI units system” and clock on “Next”



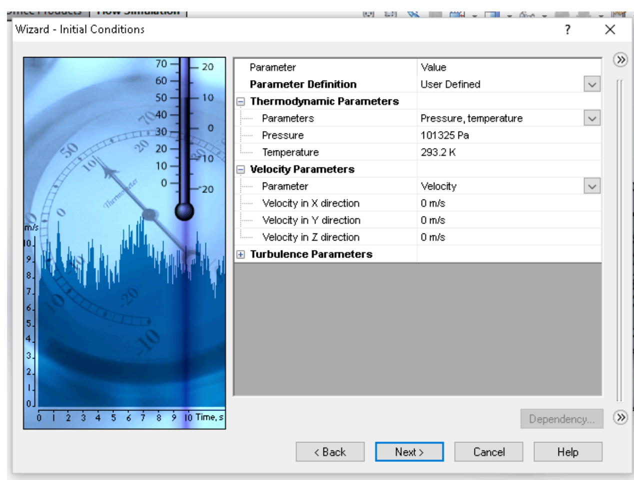
4. Click on “Internal” flow type since the test is conducted within the wind tunnel, click on “Next”



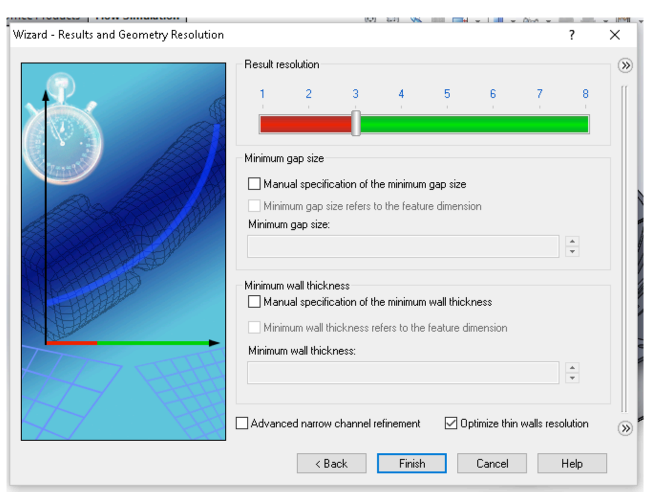
5. Select the medium in which the turbine will operate. Here it is in atmosphere so Air is chosen and added to the list and click on “Next”



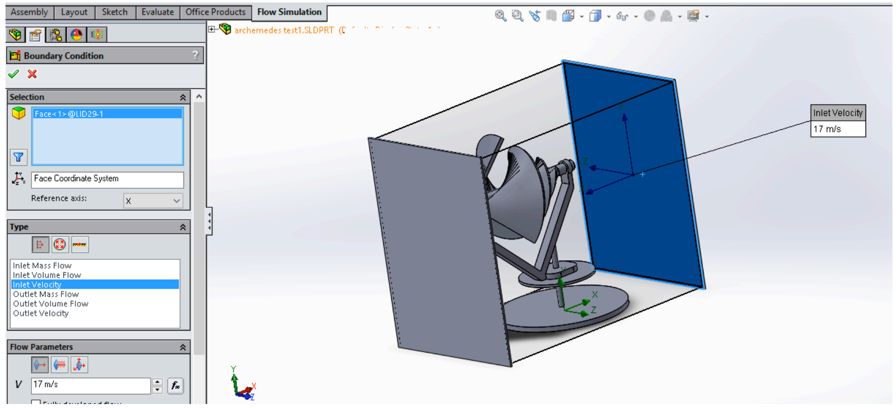
6. Check for the parameters of the medium selected and clock on “Next”



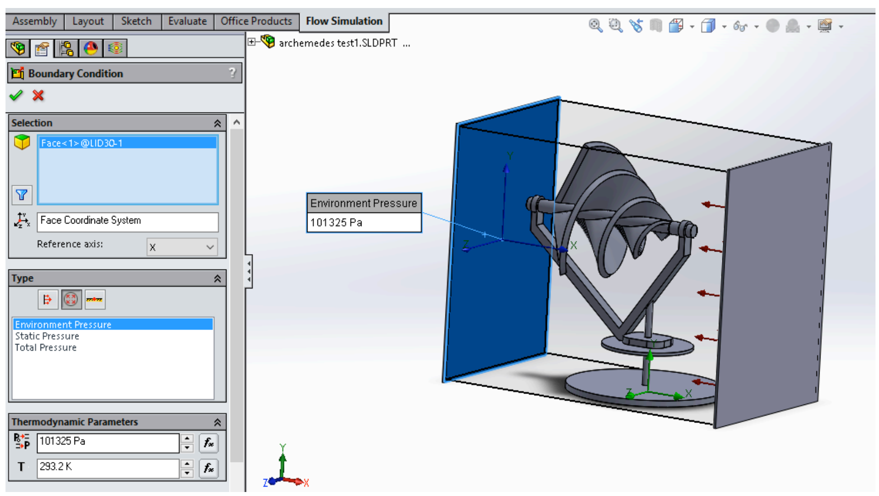
7. The resolution has to be selected inorder to provide the solver with the commamd about how accurate the approximation should be. The finer the resolution, the more accurate is the approximation.



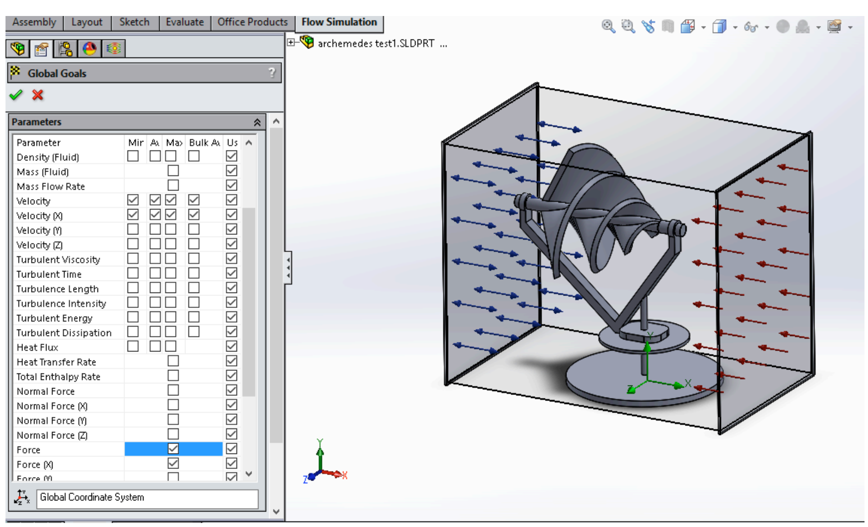
8. Select “Boundary conditions” and insert the inlet velocity on the direction towards which the turbine will be facing the train. Here the value of input velocity is input.



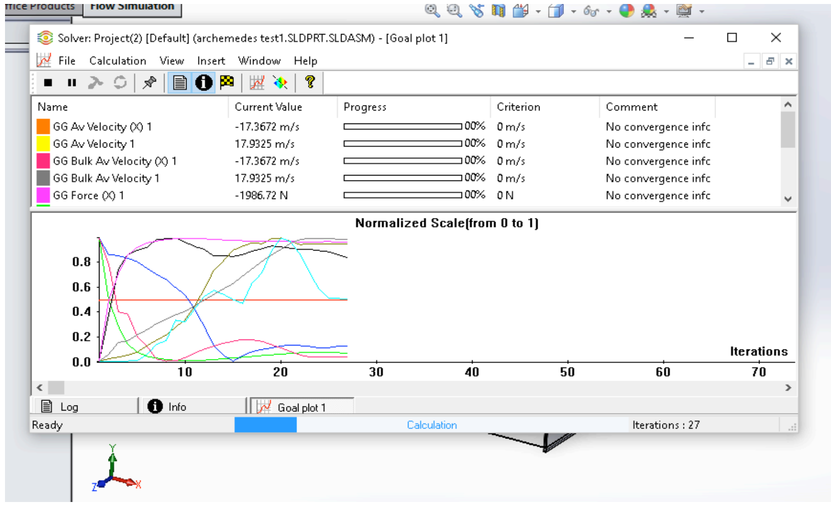
9. Select the outlet conditions similarly on the side of the wind tunnel, which is facing away from the train. Input as atmospheric conditions onto this end.



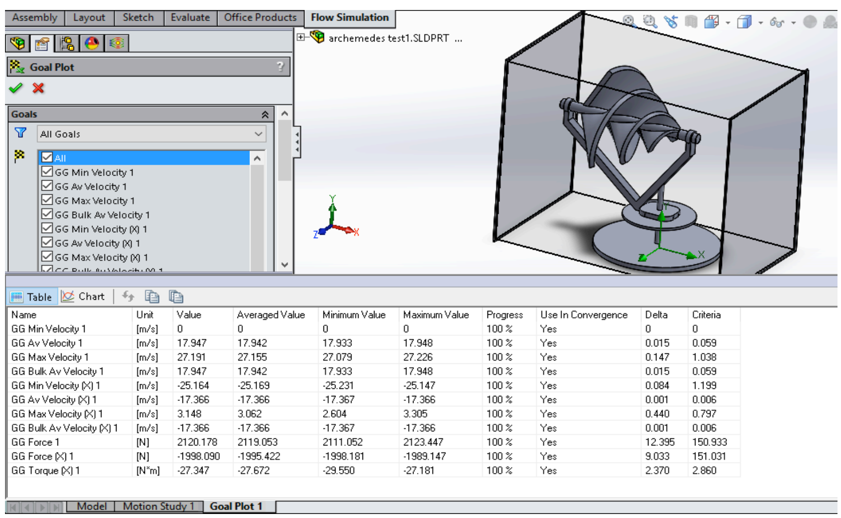
10. Click on Goal Plots and under the Global Goals, define all the parameters that the solver has to calculate by checking the boxes against the parameters.



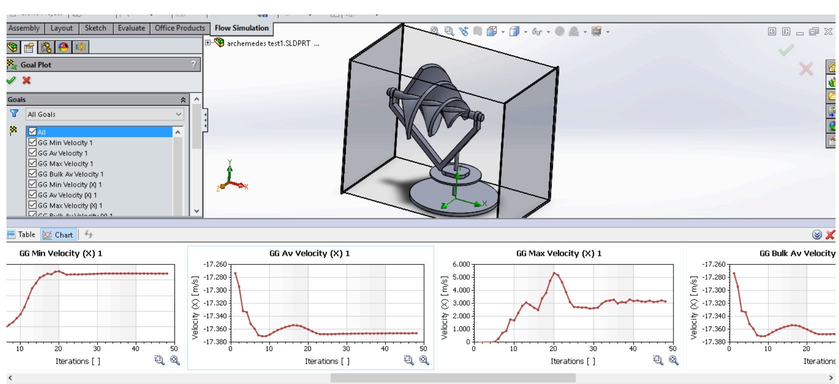
11. Click on "RUN" command to start the iteration process and wait for the results.



12. Click on Results and insert the Global Goals and plots again by selecting the parameters manually.



13. Compare results by graphical examination or by converting the result to Excel data sheet.



14. Insert the Flow Trajectories by selecting the Parameters like Velocity, Pressure, Temperature or any other required parameters. Plot the trajectory lines.

3. Charts and flow trajectory:

VELOCITY FLOW TRAJECTORIES:

The plot shows that the flow of wind from the train through the tunnel impinging on the blades of the wind turbine tends to move over the curving profile of the blades towards the central shaft depicting that the wind will cause the motion to be set in the turbine. It can be observed that the color of the lines are changing along the wind turbine generally reducing in its value from the inlet towards the outlet also providing idea that the energy is being consumed by the turbine and it is set into motion.

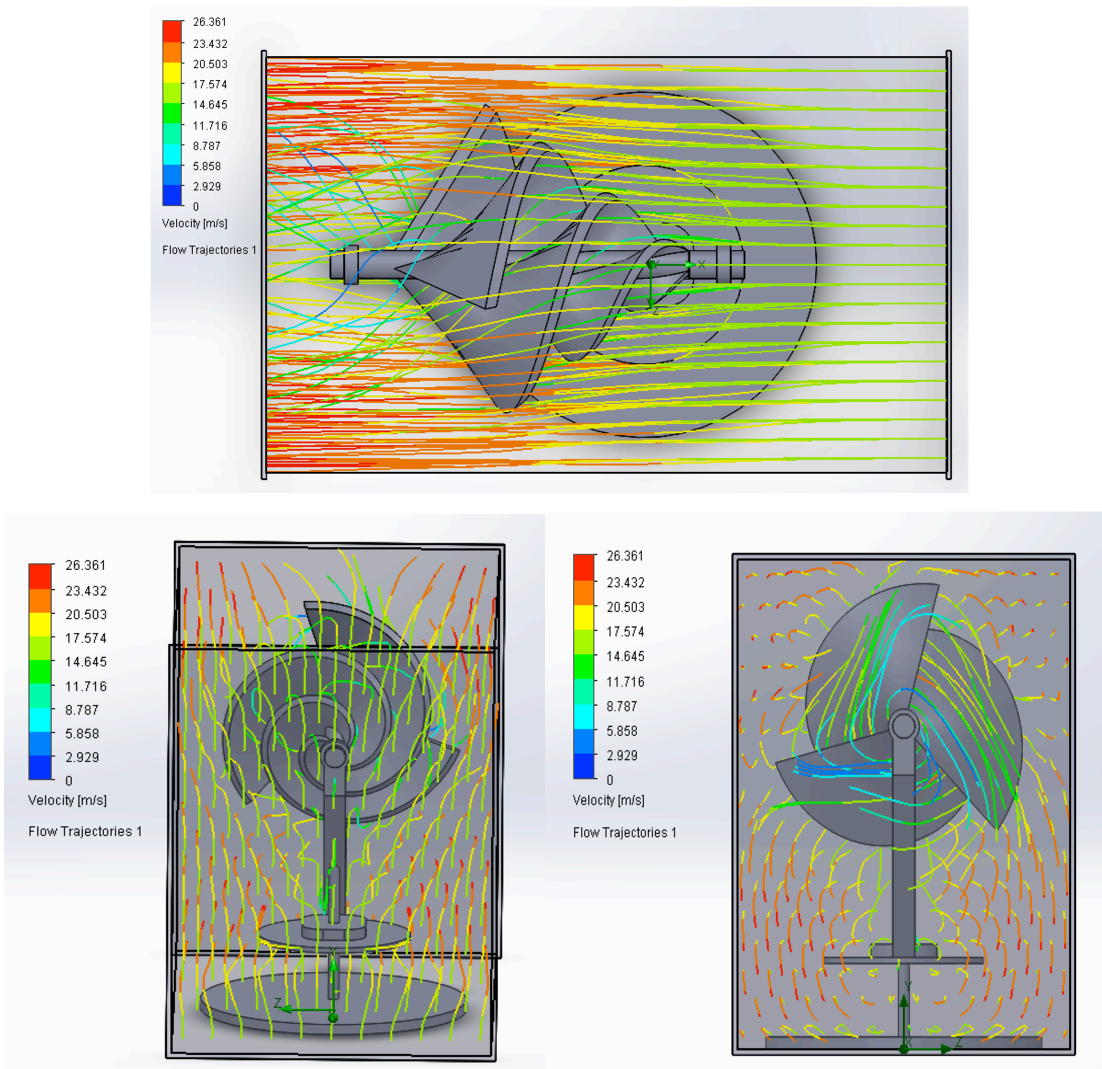


Fig 5.11: Velocity Flow Trajectories

PRESSURE FLOW TRAJECTORIES:

From the Pressure Flow Trajectory diagram it can be observed that the pressure across the turbine is gradually increasing and then decreasing along the inlet and outlet sides. Since the values are not very significantly different from the inlet and outlet sides, we can consider that the turbine is in safe working condition for the given velocity of wind.

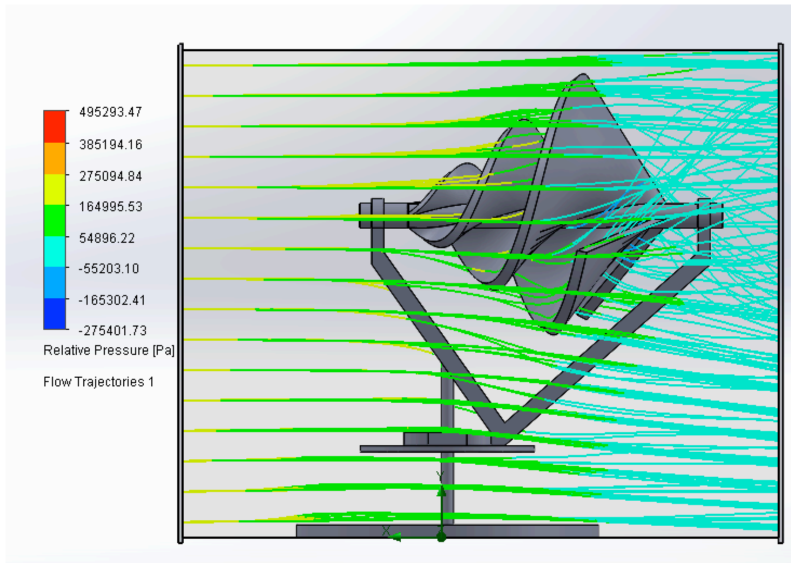


Fig 5.12: Pressure Flow Trajectories

TEMPERATURE FLOW TRAJECTORIES:

The flow lines with respect to the Temperature shows a slight increase in temperature at the central shaft of the turbine. Since the value is not very high, by choosing the material of the turbine wisely, safe working of the turbine can be easily obtained.

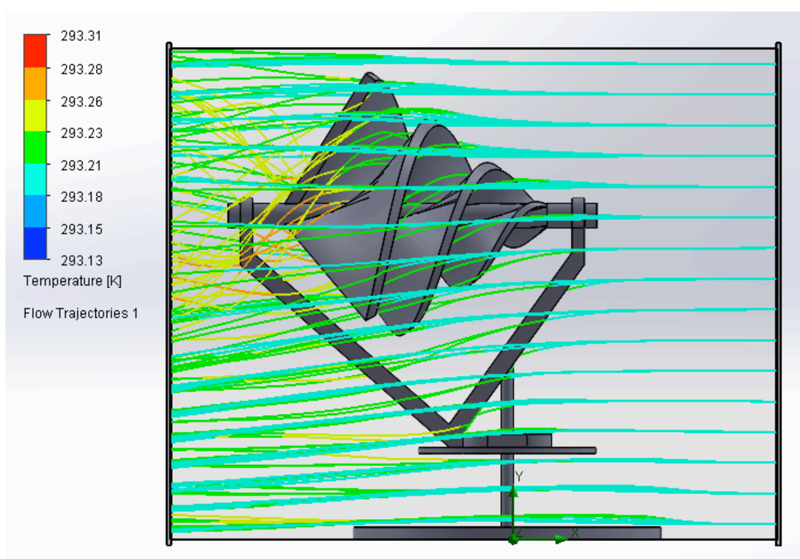
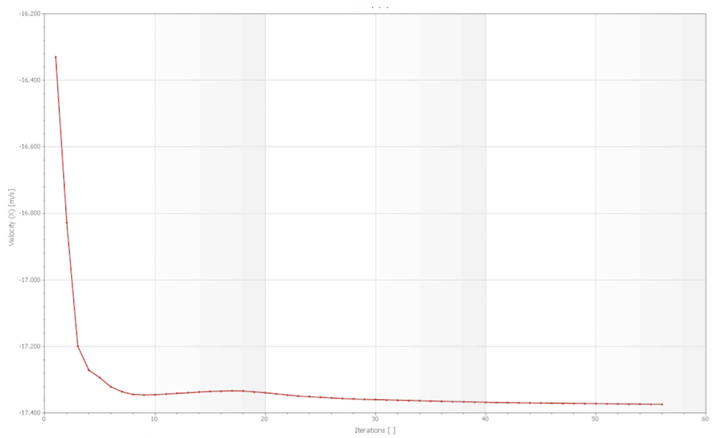


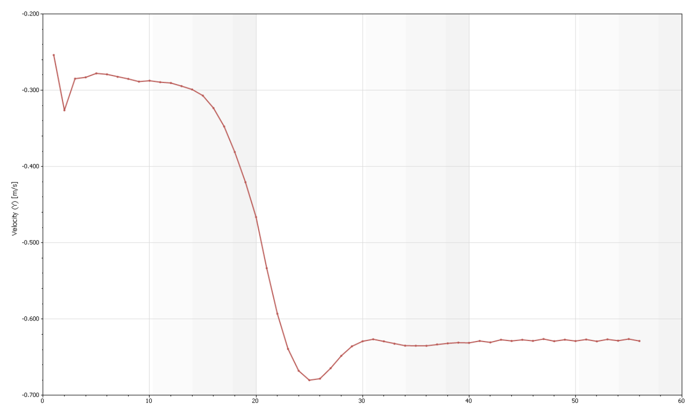
Fig5.13: Temperature `Flow Trajectories

4. Graphical representation of Flow Simulation Results:

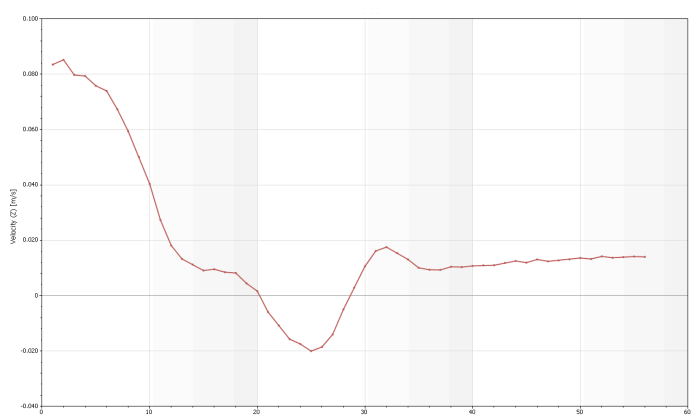
VELOCITY:



Velocity in direction - X

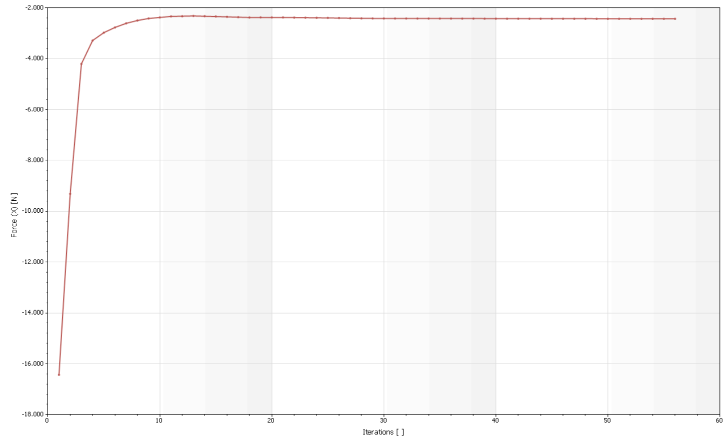


Velocity in direction - Y

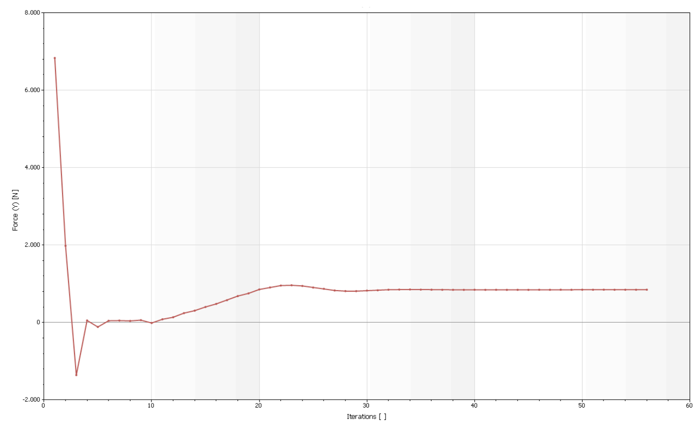


Velocity in direction – Z

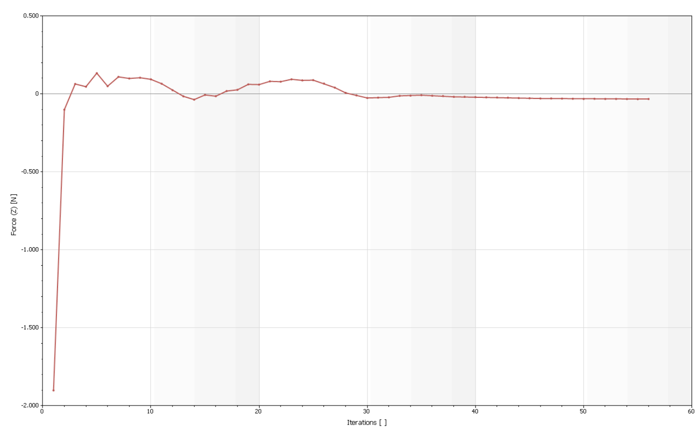
FORCE:



Force in direction - X

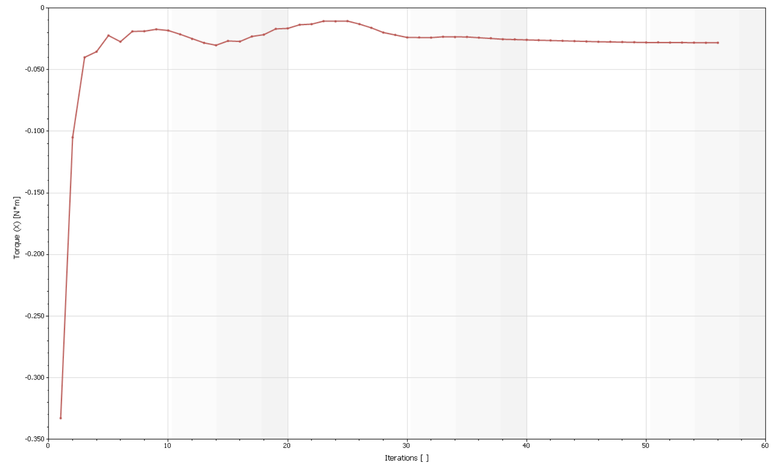


Force in direction – Y

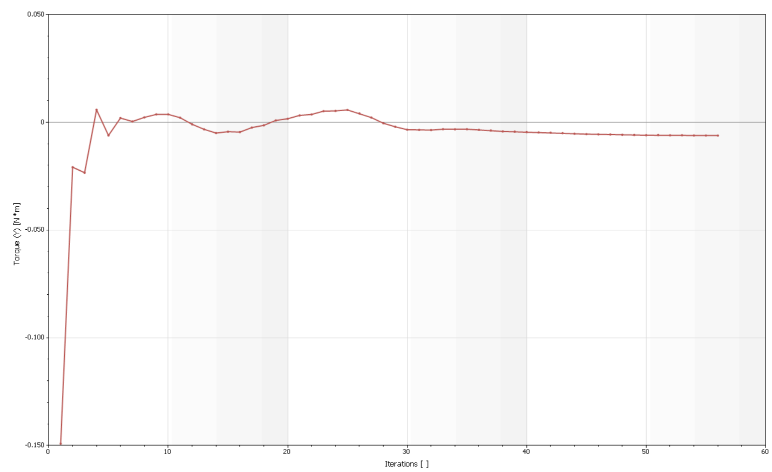


Force in direction – Z

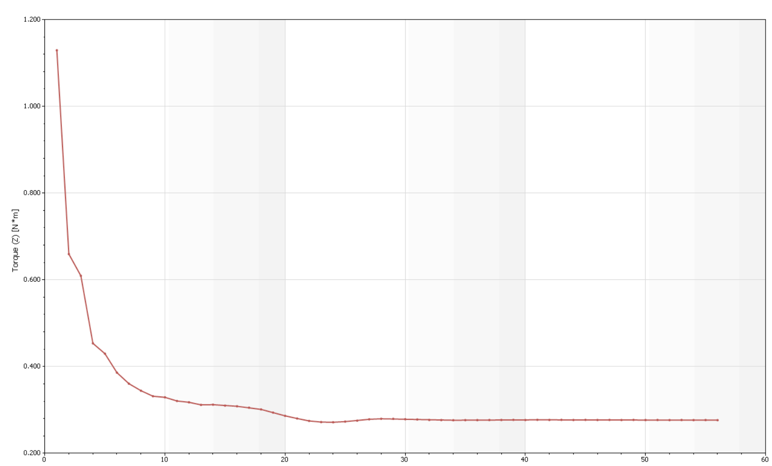
TORQUE:



Torque in direction - X



Torque in direction - X



Torque in direction – Z

EXCEL DATA SHEET: Attached in the end

5. Distance at which the turbine location (excel file and calculation):

Velocity of Wind:

$$v_W = v_t . e^{-\beta(d-2)}$$

By varying the distance between mid of track to the turbine: “d” in steps of 0.2 m, and the impact factor “B” as 0.8, 0.4 and 0.2, we obtain a graph for the best value of velocity and distance. The graphical representation makes it easy to consider the above factors.

	A	B	C	D	E	F	G	H	I	J
1	`					`	d	V_air		
2			Input velocity of train		60		2	60	60	60
3							2,2	51,12863	55,38698	57,64737
4			Input lenght of train		100		2,4	43,56894	51,12863	55,38698
5							2,6	37,127	47,19767	53,21523
6			Half with of train		2		2,8	31,63755	43,56894	51,12863
7							3	26,95974	40,2192	49,12385
8			Input impact factor		0,8		3,2	22,97357	37,127	47,19767
9							3,4	19,57679	34,27254	45,34702
10							3,6	16,68224	31,63755	43,56894
11							3,8	14,21567	29,20514	41,86058
12							4	12,11379	26,95974	40,2192
13							4,2	10,32269	24,88697	38,64219
14							4,4	8,796418	22,97357	37,127
15							4,6	7,495813	21,20728	35,67123
16							4,8	6,38751	19,57679	34,27254
17							5	5,443077	18,07165	32,9287
18							5,2	4,638284	16,68224	31,63755
19							5,4	3,952485	15,39965	30,39702
20							5,6	3,368086	14,21567	29,20514
21							5,8	2,870093	13,12271	28,05999
22							6	2,445732	12,11379	26,95974
23							6,2	2,084116	11,18244	25,90263
24							6,4	1,775966	10,32269	24,88697
25							6,6	1,513378	9,529046	23,91114
26							6,8	1,289616	8,796418	22,97357
27							7	1,098938	8,120117	22,07277
28							7,2	0,936453	7,495813	21,20728
29							7,4	0,797993	6,919507	20,37573
30							7,6	0,680005	6,38751	19,57679
31							7,8	0,579462	5,896415	18,80917
32							8	0,493785	5,443077	18,07165
33							8,2	0,420776	5,024594	17,36305
34							8,4	0,358561	4,638284	16,68224
35							8,6	0,305546	4,281676	16,02812
36							8,8	0,260369	3,952485	15,39965
37							9	0,221872	3,648604	14,79582
38							9,2	0,189067	3,368086	14,21567
39							9,4	0,161112	3,109135	13,65826
40							9,6	0,137291	2,870093	13,12271
41							9,8	0,116991	2,64943	12,60816
42							10	0,099693	2,445732	12,11379

Sheet1 Sheet2 Sheet3

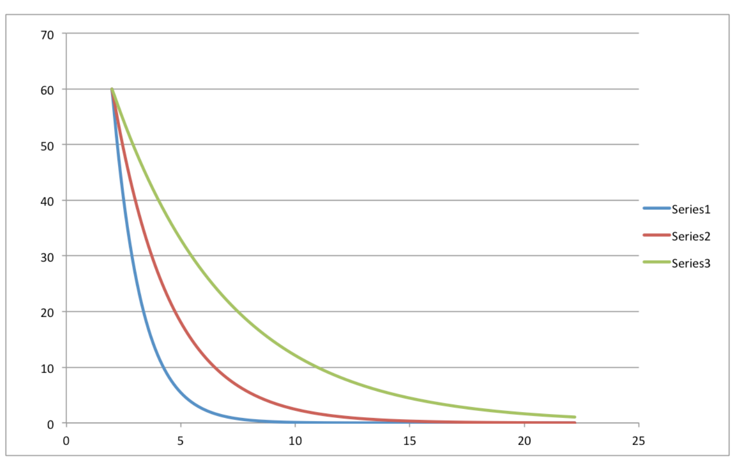


Fig 5.14: Excel data for safe distance and velocity

5.1.3 THEORETICAL CALCULATION FOR POWER OUTPOT OF THE ARCHIMEDES MODEL:

P_{in} =1/2*P*(A)(V) 3

Where, P is power in watts (W)

P is the air density in kilograms per cubic meter (kg/m3)

A is the area of blade in contact with air(m2) &

V is the wind speed in meters per second (m/s).

Consider:

P=1.25

V=17m/s

A=1/2 X d x l X 3

=1/2 X .5 X 1 X 3 = $0.75m^2$

P_{in}=1/2 X 1.25 X 0.75 $X17^3$

=2303 Watts

If we consider time factor say T=3.3sec

Power obtained for per train, per crossing for one windmill is

P_{OUT}= P_{IN} X T

=7668.99 W/s, = $2.13X10^{-3}$ KW/h

5.2 PROPOSED MODEL NUMBER 2:

5.2.1 *THE SAVONIUS WIND TURBINE:*

LITERATURE REVIEW FOR THIS MODEL:

Today, the most commonly used wind turbine is the Horizontal Axis Wind Turbine (HAWT), where the axis of rotation is parallel to the ground. However, there exist other types of wind turbines, one of which will be the primary focus of this paper, the Vertical Axis Wind Turbine (VAWT). These devices can operate in flows coming from any direction, and take up much less space than a traditional HAWT, and VAWT are definitely a credible source of energy for the future. VAWTs have a number of advantages over HAWTs, such as:

- Simple construction, they can be made from oil barrels cut in two halves.
- Extremely (low cost), simplicity reduces cost of construction, and aids installation.
- They can accept wind from any direction, thus eliminating the need for re-orienting towards the wind.

VAWTs work well in places with relatively low wind strength, and constant winds, VAWTs include both a drag type configuration, such as the Savonius rotor, and a lift-type configuration, such as the Darrieus rotor.[12]

PRINCIPLE OF SAVONIUS ROTOR WIND TURBINE:

Savonius turbines are one of the simplest turbines. Aerodynamically, they are drag-type devices, consisting of two or three blades (vertical – half cylinders). A two blades Savonius wind turbine would look like an "S" letter shape in cross section. The Savonius wind turbine works due to the difference in forces exert on each blade. The lower blade (the concave half to the wind direction) caught the air wind and forces the blade to rotate around its central vertical shaft. Whereas, the upper blade (the convex half to wind direction) hits the blade and causes the air wind to be deflected sideway around it.[12]

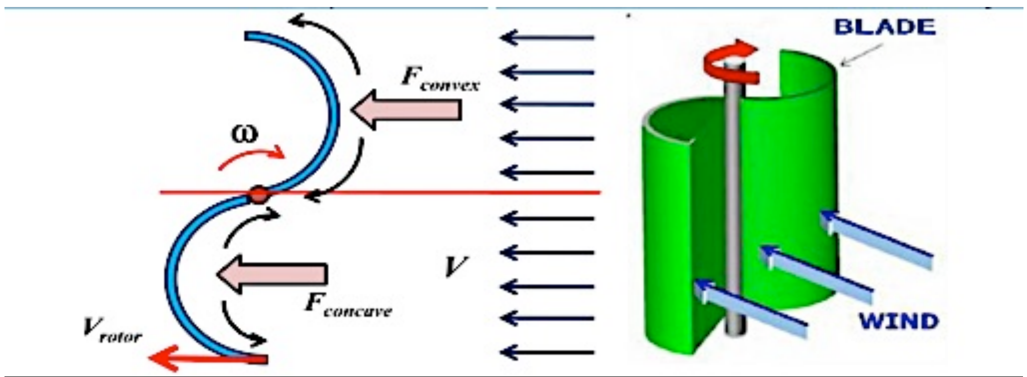


Fig 5.15: Working of Savonius Turbine

Because of the blades curvature, the blades experience less drag force (F_{convex}) when moving against the wind than the blades when moving with the wind ($F_{concave}$). Hence, the half cylinder with concave side facing the wind will experience more drag force than the other cylinder, thus forcing the rotor to rotate. The differential drag causes the Savonius turbine to spin. For this reason, Savonius turbines extract much less of the wind's power than other similarly sized lift type turbines because much of the power that might be captured has used up pushing the convex half, so Savonius wind turbine has a lower efficiency.

Savonius wind rotor basics:

Figure shows the basic parameters needed to calculate power and rotational speed of a Savonius wind rotor

Parameters:

d – diameter of plastic pipe [m]
D – wing spread of rotor [m]
e – pipe spacing [m] h – height of blades / tubes [m]
v – wind speed [m/s]
F – diameter of end plates [m]

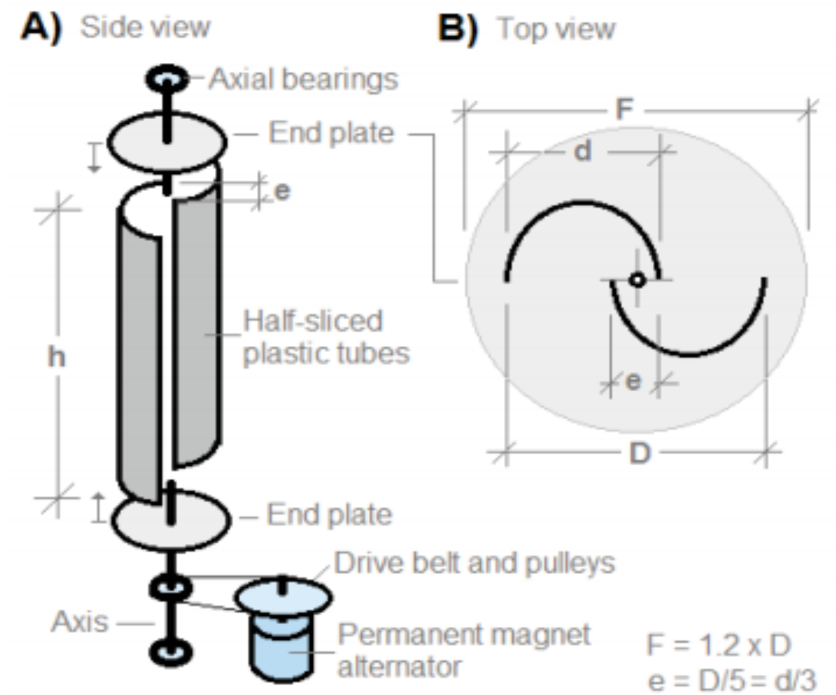


Fig 5.16: Basic design idea for Savonius Turbine

Basic equations, the maximum power of the rotor is estimated according to Betz's law

$$P_s = {}^1\!/_2\ \rho \cdot A \cdot v^3 \cdot C_p = 0.36 \cdot h \cdot D \cdot v^3. \quad [W]$$

ρ=1.2 kg/m3 is the air density, A=h.D the sweep area of the rotor blade and Cp=0.593 the Betz coefficient. However, there are aerodynamic and mechanical losses in the order of 50%. Our rotor shaft power equation then becomes

$$P_s = 0.18 \cdot h \cdot D \cdot v^3. \quad [W]$$

The rotational speed is defined as

$$n = (60/2\pi) \cdot \omega \quad , [rpm]$$

Where $\omega = \lambda \cdot v/r$ is the angular velocity in units of radians per second, r=D/2 the radius of the rotor and λ= 1 the tip-speed ratio. Furthermore, the torque at the rotor shaft is given as

$$\tau_s = P_s/\omega. \quad [Nm]$$

It is now possible to calculate key parameters of the rotor using the above equations. For simplicity, the height of the rotor is h=1m. New power and torque values as a function of h are found by linear scaling of the calculated unit values. The rotor should start spinning for wind conditions defined as moderate breeze or wind start speed v = 6 m/s.

The results are shown in Table below:

Rotor #	d [cm]	e [cm]	D [m]	r [m]	ω [rad./s]	n[rpm]	P_s [W]	τ_s [Nm]
1	10	3.33	0.167	0.0835	71.856	686	6.50	0.09
2	20	6.66	0.333	0.1665	36.036	344	12.95	0.36
3	30	10.0	0.500	0.2500	24.000	229	19.44	0.81

Table 2: Rotor parameters

By using above literature we designed two types of Savonius wind turbines in solid works software and tried to solve the flow simulation, below are the details of those.

5.2.2 Considering the above study, two designs for the wind turbine to generate electricity beside the railway track have been made as follows:

1. Design:

Design 1: Two Blades

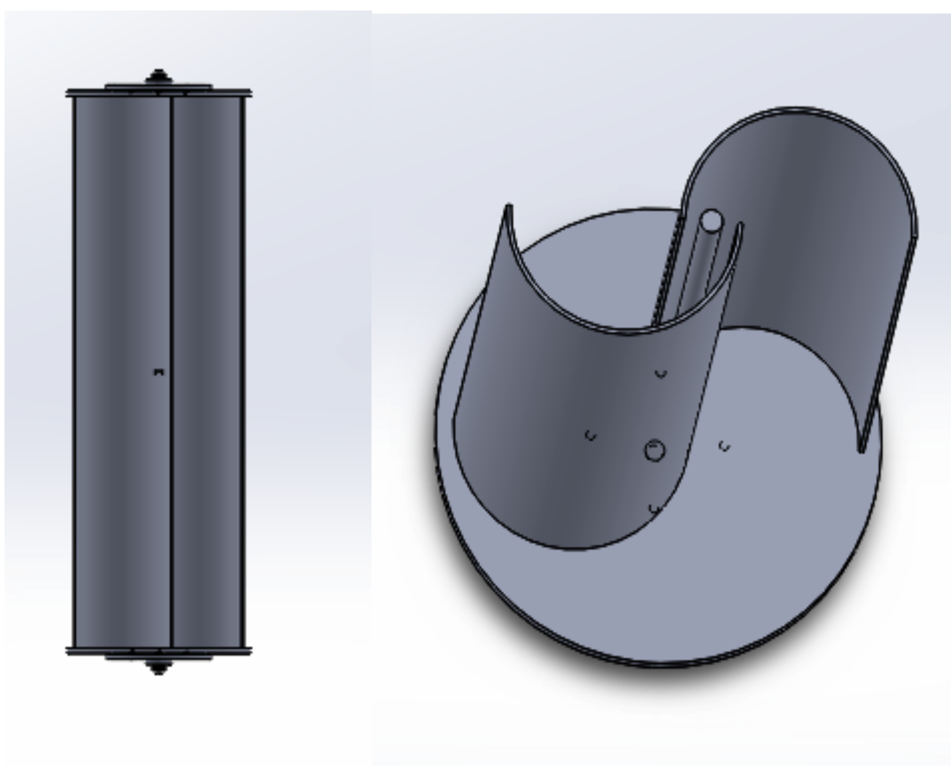


Fig 5.17: Savonius Turbine with two blades

Design 2: Six Blades

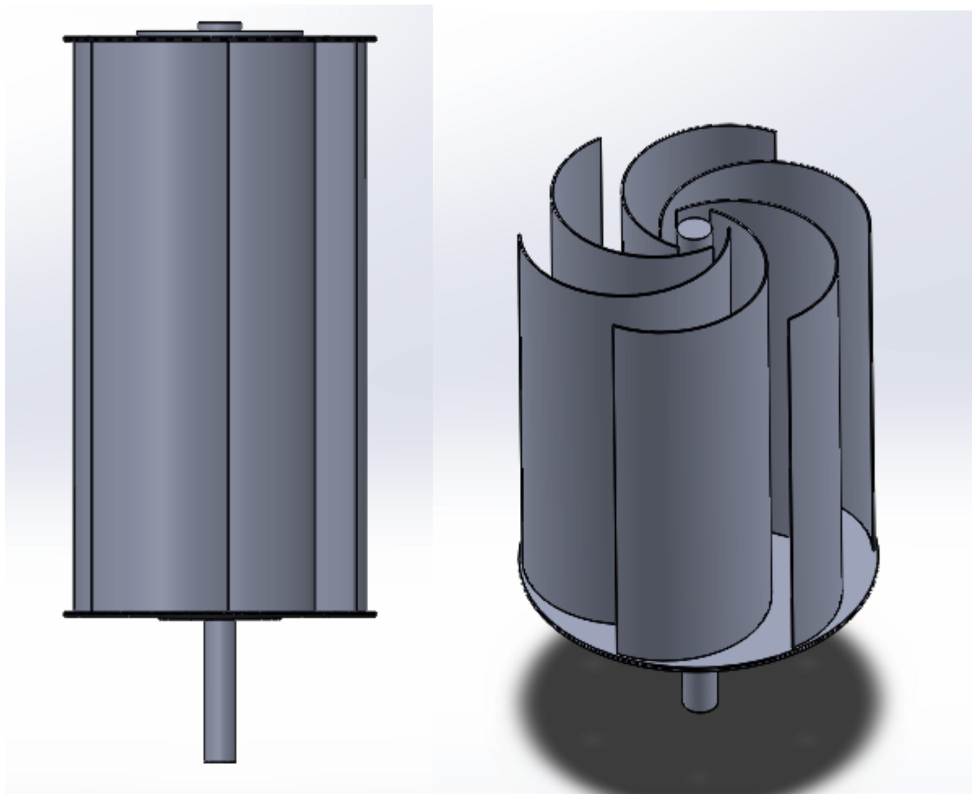


Fig 5.18: Savonius Turbine with Six blades

2. Flow simulations and its procedure:

The procedure for Flow Simulation remains the same as performed in the analysis for the Archimedes Turbine.

The procedure involves in:

- Selecting parameters
- Medium of operation and conditions
- Resolution size of solver calculation
- Inputs for boundary conditions
- Setting up Global Goals
- Plotting Flow Trajectories
- Examining the graphical results
- Excel data sheets

Boundary Conditions:

- Inlet Velocity: 17m/s
- Outlet conditions remain same as the working medium

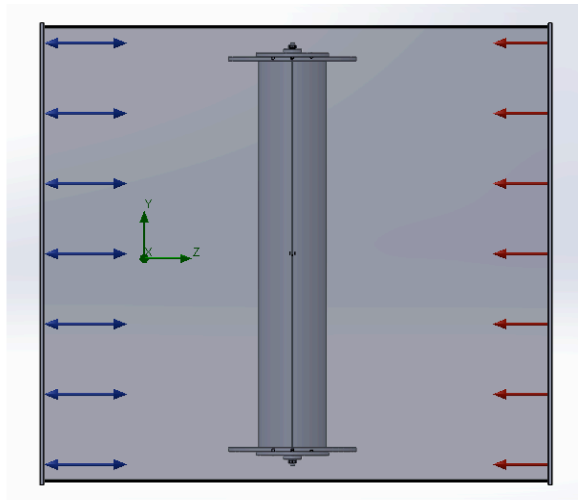


Fig 5.19; Boundary conditions for turbine with two blades

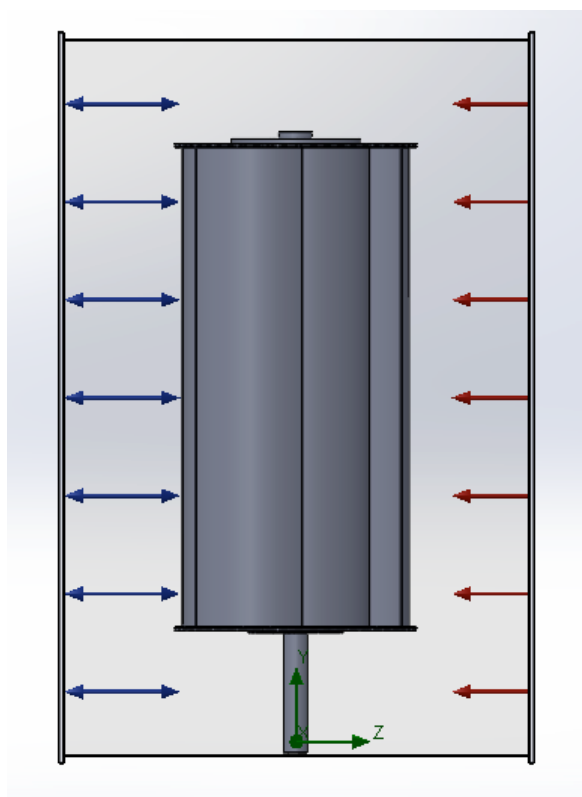


Fig 5.20; Boundary conditions for turbine with six blades

3. Charts and flow trajectory:

<u>VELOCITY FLOW TRAJECTORIES:</u>

The plot shows that the flow of wind from the train through the tunnel impinging on the blades of the wind turbine tends to move over the curving profile of the blades towards the central shaft depicting that the wind will cause the motion to be set in the turbine. It can be observed that the color of the lines are changing along the wind turbine generally reducing in its value from the inlet towards the outlet also providing idea that the energy is being consumed by the turbine and it is set into motion.

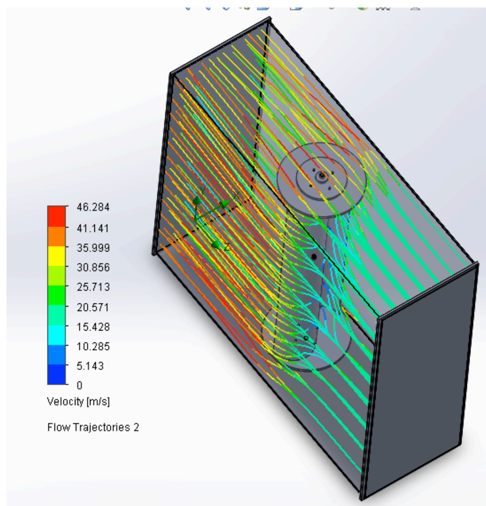


Fig 5.21: Velocity Flow Trajectories for Turbine with two blades

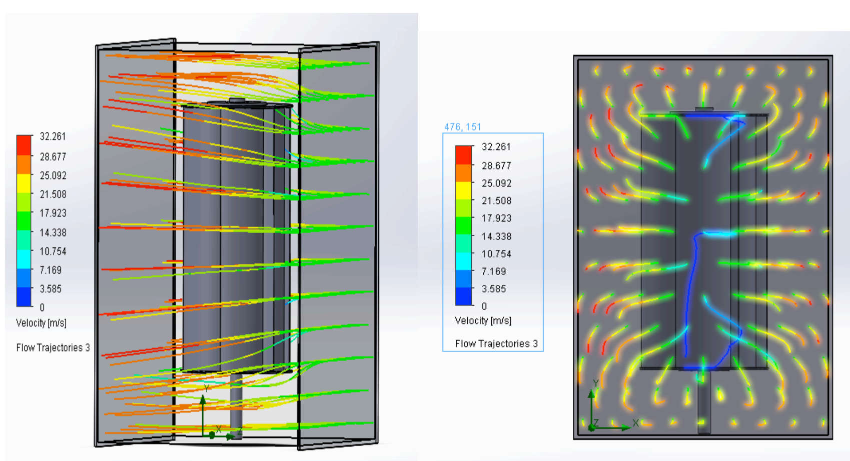


Fig 5.22: Velocity Flow Trajectories for Turbine with six blades

Comparing the trajectory lines, it is evident that the utility if the wind input is more on the turbine with six blades. Hence the output in this turbine is expected to be higher.

PRESSURE FLOW TRAJECTORIES:

From the Pressure Flow Trajectory diagram it can be observed that the pressure across the turbine is gradually increasing and then decreasing along the inlet and outlet sides. Since the values are not very significantly different from the inlet and outlet sides, we can consider that the turbine is in safe working condition for the given velocity of wind.

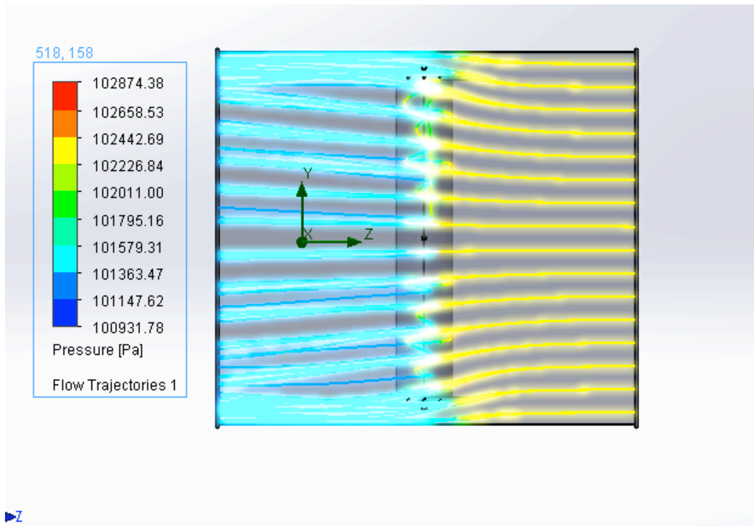


Fig 5.23: Pressure Flow Trajectories for Turbine with two blades

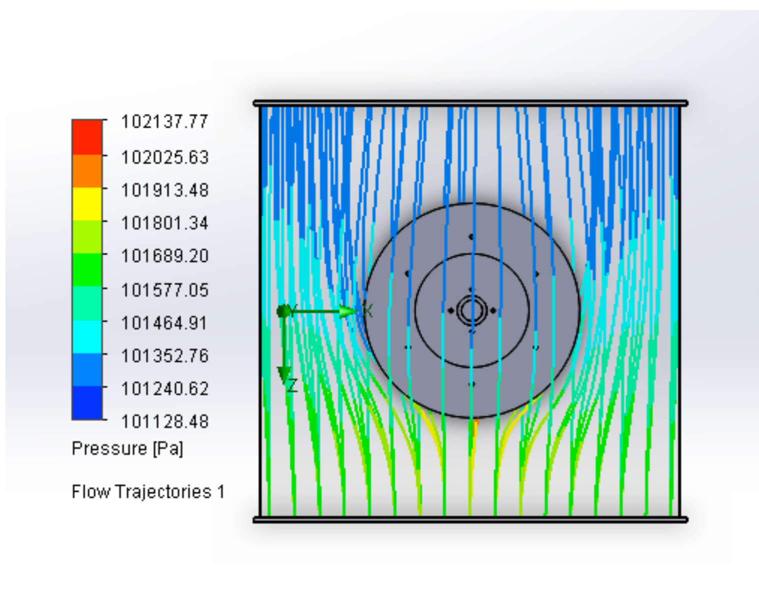


Fig 5.24: Pressure Flow Trajectories for Turbine with six blades

TEMPERATURE FLOW TRAJECTORIES:

The flow lines with respect to the Temperature shows a slight increase in temperature at the central shaft of the turbine. Since the value is not very high, by choosing the material of the turbine wisely, safe working of the turbine can be easily obtained.

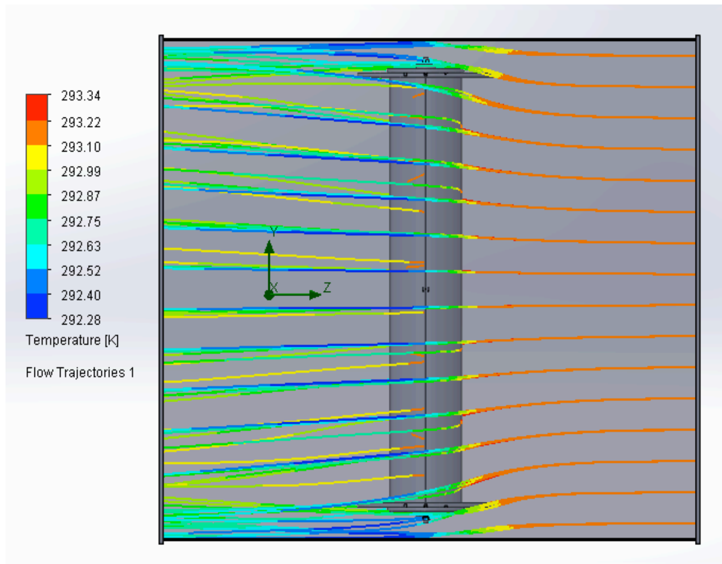


Fig 5.25: Temperature Flow Trajectories for Turbine with two blades

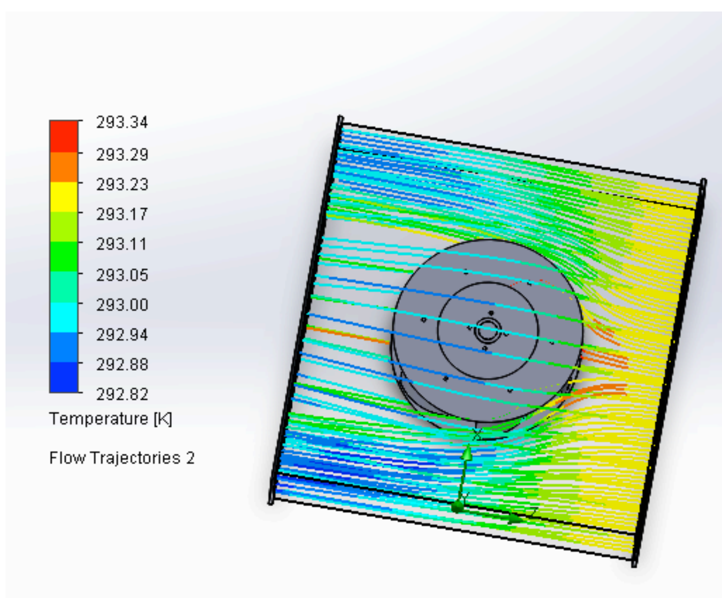


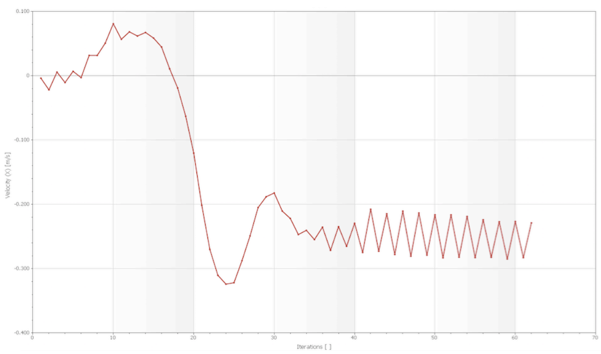
Fig 5.26: Temperature Flow Trajectories for Turbine with six blades

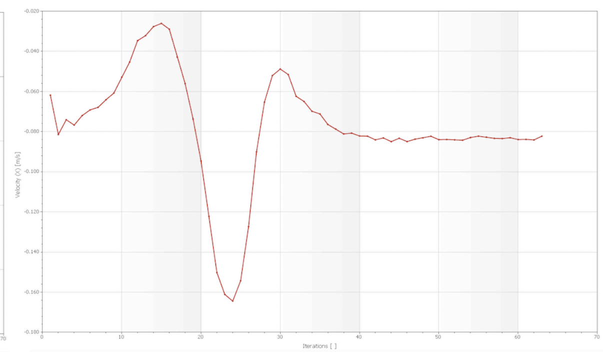
5. Graphical representation of Flow Simulation Result:

(a) Representing turbine with two blades

(b) Representing turbine with six blades

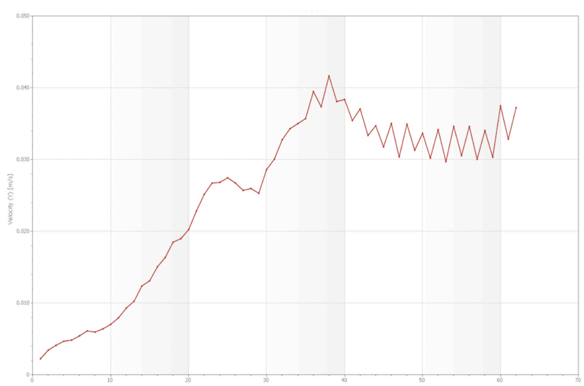
<u>VELOCITY:</u>

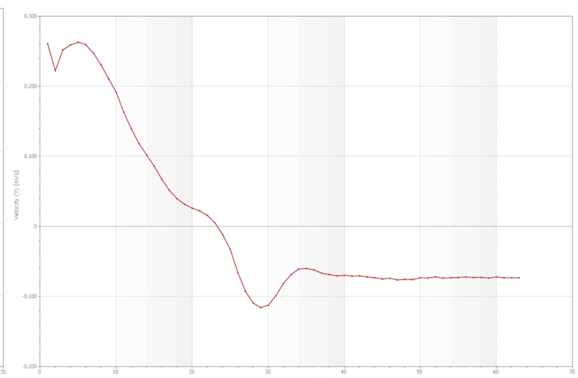




(a) **(b)**

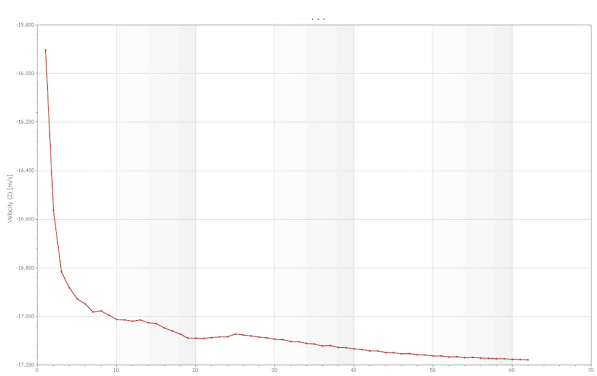
Velocity in direction - X

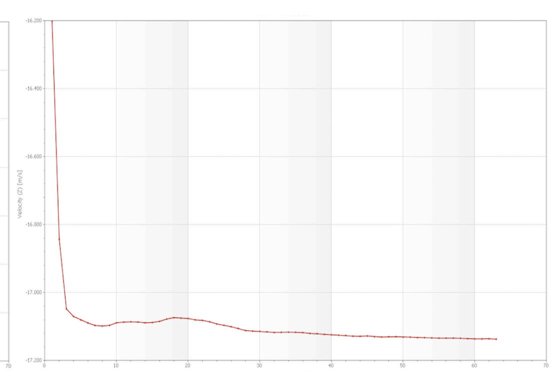




(a) **(b)**

Velocity in direction – Y

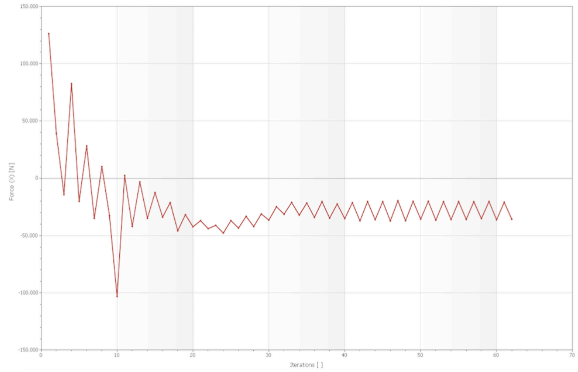


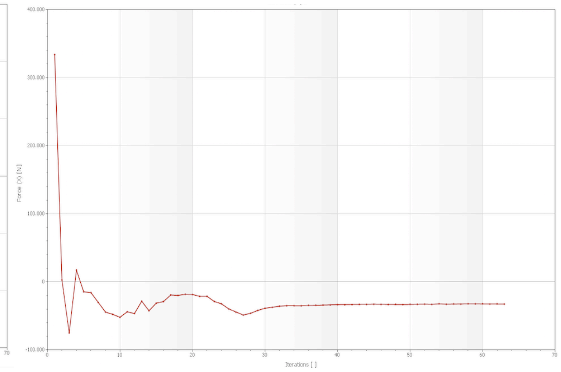


(a) **(b)**

Velocity in direction – Z

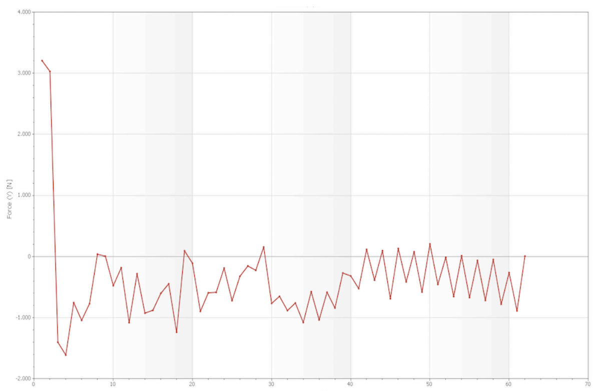
FORCE:

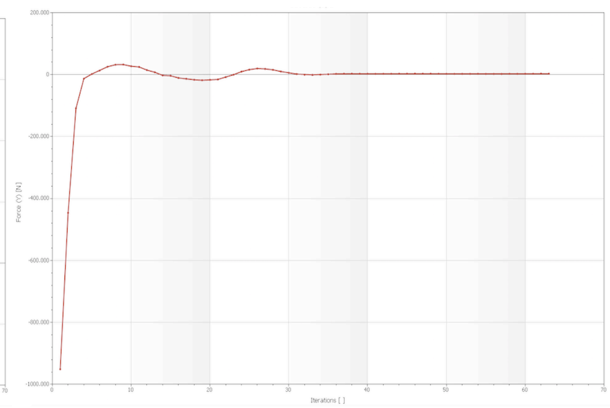




(a) **(b)**

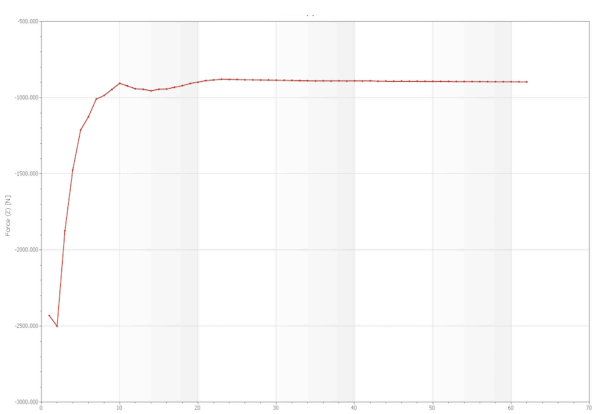
Force in direction – X

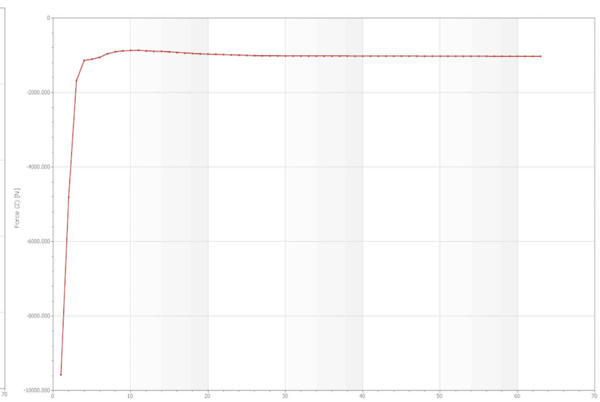




(a) **(b)**

Force in direction – Y

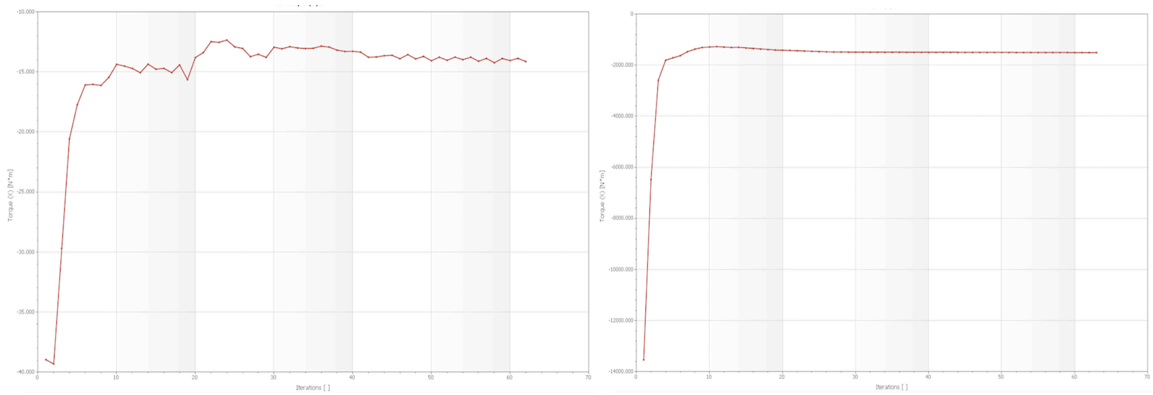




(a) **(b)**

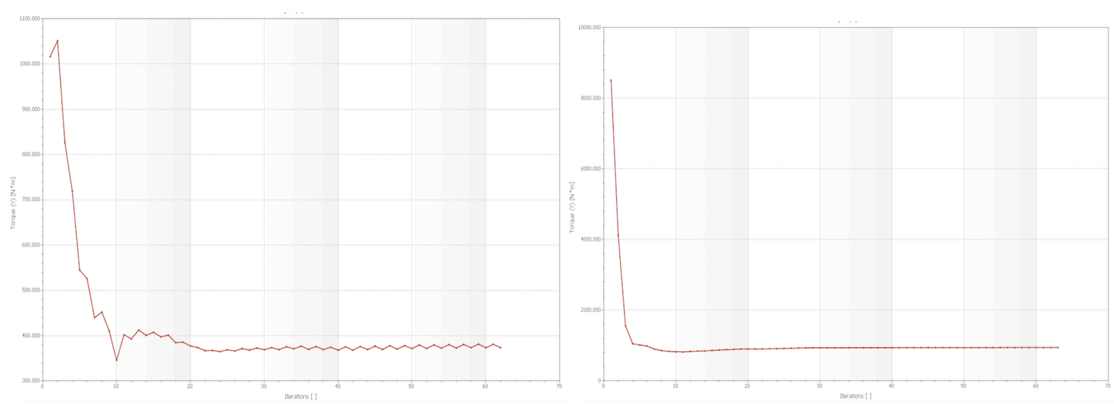
Force in direction – Z

TORQUE



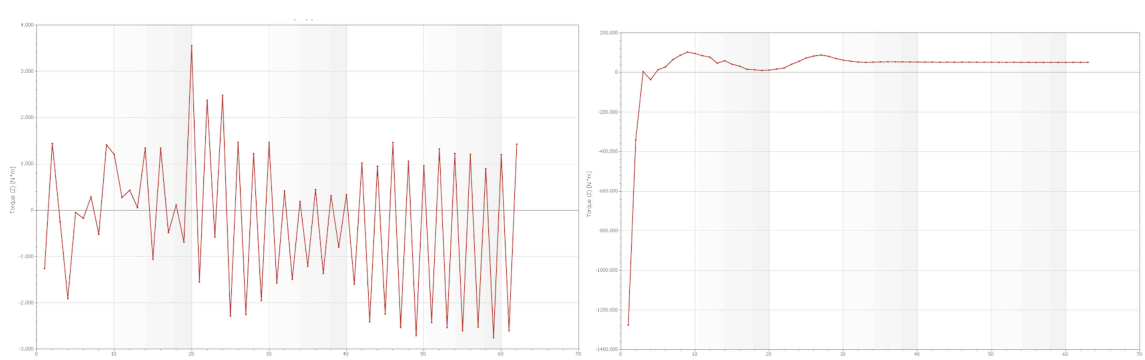
(a) **(b)**

Fig: Torque in direction – Y



(a) **(b)**

Fig: Torque in direction – Y



(a) **(b)**

Fig: Torque in direction – Z

EXCEL DATA SHEET: Attached in the end

Comparison:

The graphical representations of the results for the same input conditions are plotted above. The observation of these plots, results that the two bladed Savonius turbine shows some turbulent curves and hence doesn't cooperate well in the smooth operation of the system. The turbulent behavior will lead to further problems in the components attached to the turbine, incurring an increase in the maintenance costs.

Where as the six bladed Savonius turbine shows a smooth curve and hence is better for our situation and input conditions.

A question may arise regarding the number of blade. Is it better to have more than six blades for smoother operation? The answer would be yes but in this case, the time for which the wind is in contact with the blades is very less and hence increased number of blades may lead to reduction in output from the turbine as the flow of wind may pass across the blades without doing any useful work.

5.2.3 THEORETICAL CALCULATION FOR POWER OUTPUT OF THE SAVONIUS MODEL:

Volume: $V = hx2R$
$V = 2hvtR$

Mass: $m = V\rho$
$m = 2hvtR\rho$

Kinetic Work: $W_K = \rho h R v^3 t$

Wind Power: $P_W = \frac{W_K}{t}$

$P_W = \frac{\rho h R v^3}{3}$

Mechanical Power: $P_M = \eta_M \rho h R v^3$

Electrical Power: $P_E = \eta_M \eta_E \rho h R v^3$

Power of Air: $P_{air} = \rho h R v^3$

Velocity of Wind: $v_W = v_t . e^{-\beta(d-2)}$

$\beta = 0.2$

$d >= 2$

Velocity of Train: $v_t = 30$ m/s

Considering: $\beta = 0.2$

d = 5 m

$v_W = 17$ m/s

$P_{air} = 12282.5$ Watts

$W_E = P_{air}\, t$
$= 12282.5 \text{ X } (100/30)$
$= 40941.66$ Ws

h= 2 m
R= 1 m
$\rho = 1.25\ \text{kg/m}^3$

t= 100/30
= 3.33 s

$P_E = 0.27 \times 0.9 \times 12282.5$
$= 2984.65$ W

Electrical Energy: $E_E = P_E t$
$= 2984.65 \times 3.33$
$= 98489.33$ W/s
$= 2.8 \times 10^{-3}$ kW/H

5.3 COMPARISON OF RESULTS FOR THE TWO MODELS BESIDE THE TRACK:

Number of trains	Total distance traveled by train	Archimedes Turbine Power (x10-3)	Savonius Turbine Power (x10-3)
1	100	2.13	3.07
2	200	4.26	6.14
3	300	6.39	9.21
4	400	8.52	12.28
5	500	10.65	15.35
6	600	12.78	18.42
7	700	14.91	21.49
8	800	17.04	24.56
9	900	19.17	27.68
10	1000	21.3	30.7

Table 3: Comparison of results for Archimedes and Savonius wind turbines.

The table above represents the values of the output obtained from the two models proposed, as a factor of the number of trains and the distance of passing across one turbine. It can be seen that the values of the Savonius turbine are higher. But considering the fact that the dimensions of the Archimedes turbine are half as that of the Savonius turbine, the Archimedes turbine is a better value for us for the price and the output.

As it may seem that the Archimedes turbine produces similar quantity of output with a relatively smaller dimension of the turbine, there is a consideration required for the design of the two models. The design for the Savonius Model is much simpler and easy to manufacture. On the other hand, Archimedes turbine is a more complex in design and not very easy to be manufactured.

CHAPTER 6:

INVESTIGATION OF THE PARAMETERS OF HARNESSING WIND ENERGY BY ARRANGEMENT OF WIND TURBINES ON TRAIN TOP

6.1 Selection of wind turbine:

The turbine should not pan on the oscillation or the vibration into the vehicle and the turbine weight should be balanced. For this method, a horizontal swift turbine is used. Swift turbine is a structure or pole mountable wind turbine with a quit operation. Traditional wind turbine generates some noise as the wind travels the length of the blades, while the outer ring on swift acts as a diffuser. As the wind travels down the blades it is dispersed along the outer ring, significantly reducing the round and keeping the turbine quiet.

6.2 Explanation:

The wind turbine is mounted on roof surface of a train with rigid support. The turbine blade is provided or covered with vertical to provide safety from huge wind pressure. The turbine is placed in such a way that it gets maximum support and extract maximum power from turbine.[14]

6.3 Working: ·

- When the train moves with an average speed, the wind turbine attached to it also rotates. ·
- The turbine should be placed in such a way that the wind strikes the blades. This gives the turbine a rotational movement.
- The turbine is placed along the path of the wind flow path that is mounted on the train, then the blade rotates and energy is generated. When the train moves, the turbine rotates and this rotational energy can be converted into electrical energy that provides power to the various loads such as fans and lights etc. We can also store the excess change in battery that can be used for further use.

6.4 Storage of electrical energy:

- The rotational movement of the rotor blade is converted into electrical energy by the generator.
- For domestic purposes a permanent magnet generator is used.

- Permanent magnet generators use the high-field strength generated by magnets mounted on rotor.
- Variations on this design put magnets on the stator and let the coils rotate. The electric energy then can be used in for other domestic uses.
-

6.5 CONCEPT:

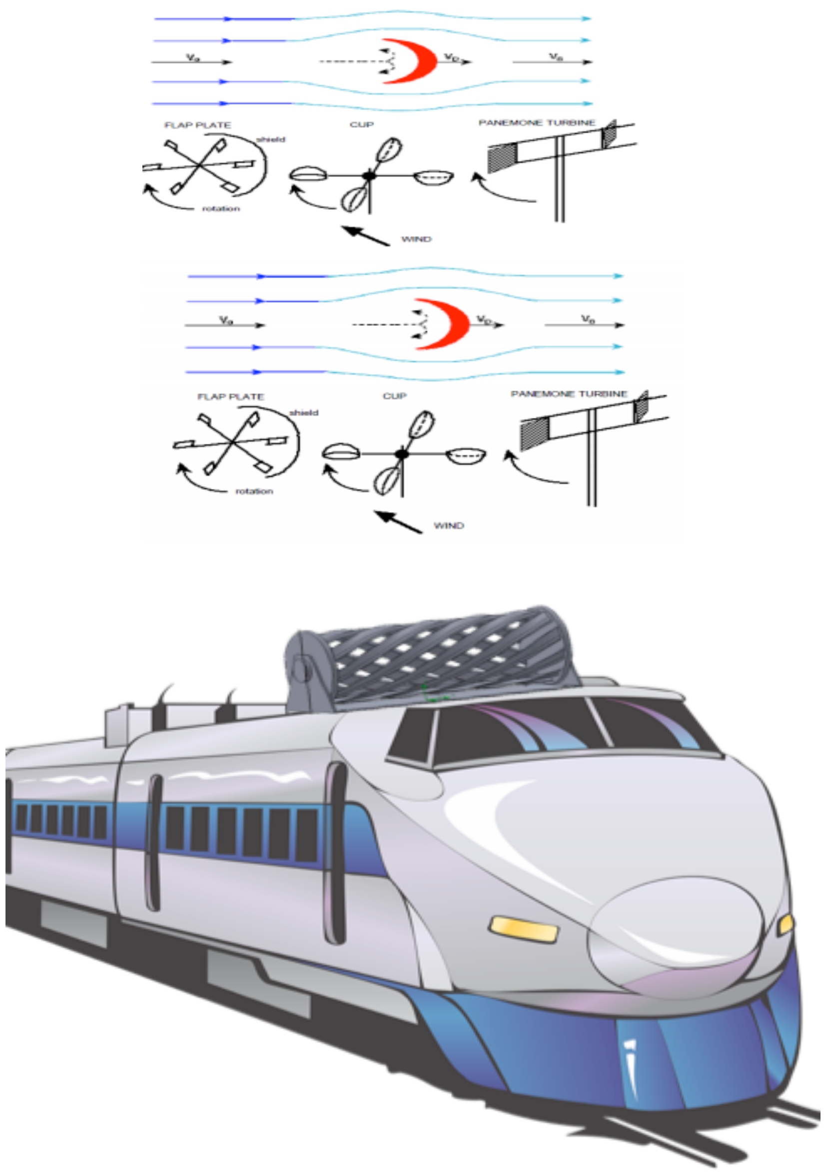


Fig 6.1: Concept for train top model

CHAPTER 7:

PROPOSED TRAIN TOP MODEL WIND TURBINE DESIGN:

The proposed model uses vertical axis wind turbine (VAWT). Reasons for selecting VAWT over horizontal axis turbine (HAWT) are:

- The HAWT type turbines obstruct the train's forward motion by exerting a force against its propulsion.
- The structural properties of the HAWT type turbines induce a lot of force against the supporting structures at high velocities, which arises the necessity of more complex design and utilization of supporting structures.
- High thrust developed over horizontal axis turbines develops fatigue loads.
- The wind energy developed excessively during train's propulsion is concentrated on the surface thrust of the HAWT, so the useful power input is lost.
- The self starting capability and starting torque of VAWT is high.
- One of the major advantages of the VAWT implementation is that it has directional flexibility in using the wind energy as input. Allowing it to be functional even when the train is moving in the reverse direction, unlike the HAWT that need a shifting blade mechanism to operate in different direction.

Improvisation in technology has made VAWT designs much efficient and easy. Fig shows the different VAWT turbines that can be used.

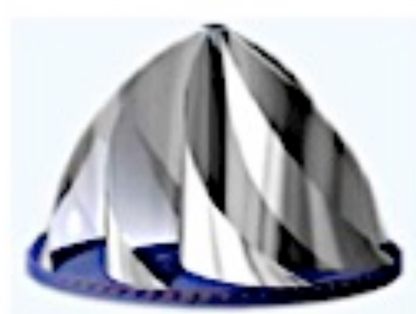


Fig 7.1: Model idea for Design

7.1 Considering the above literature, two designs for the wind turbine to generate electricity beside the railway track has been made as follows:

1. Design:

Design 1:

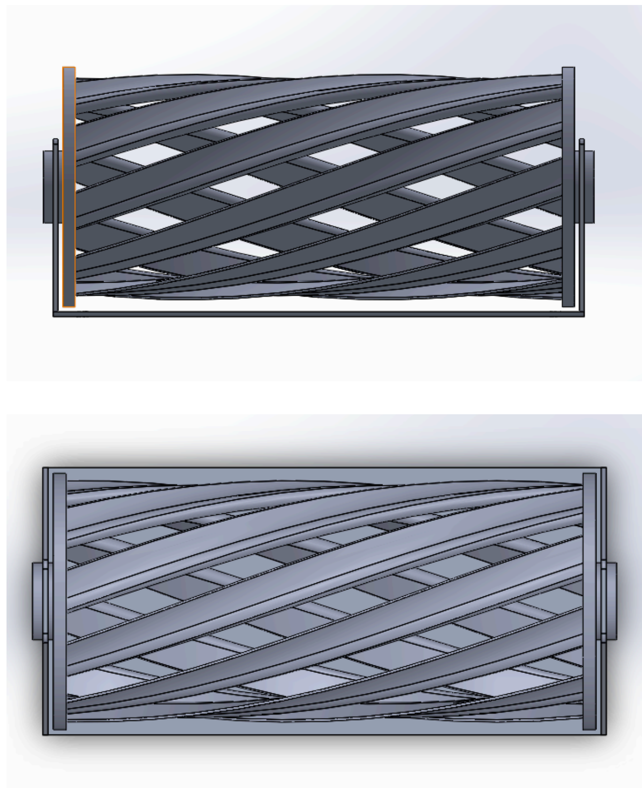


Fig 7.2: Horizontal Axis Wind Turbine Design for Train Top

Design 2:

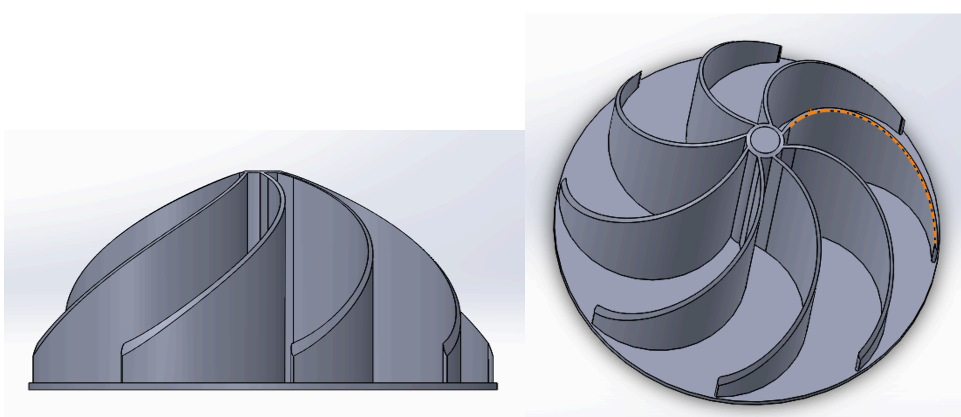


Fig 7.3: Vertical Axis Wind Turbine Design for Train Top

2. Flow simulations and its procedure:

The procedure for Flow Simulation remains the same as performed in the analysis for the Archimedes Turbine.

The procedure involves in:

- Selecting parameters
- Medium of operation and conditions
- Resolution size of solver calculation
- Inputs for boundary conditions
- Setting up Global Goals
- Plotting Flow Trajectories
- Examining the graphical results
- Excel data sheets

Boundary Conditions:

- Inlet Velocity: 30 m/s
- Outlet conditions remain same as the working medium

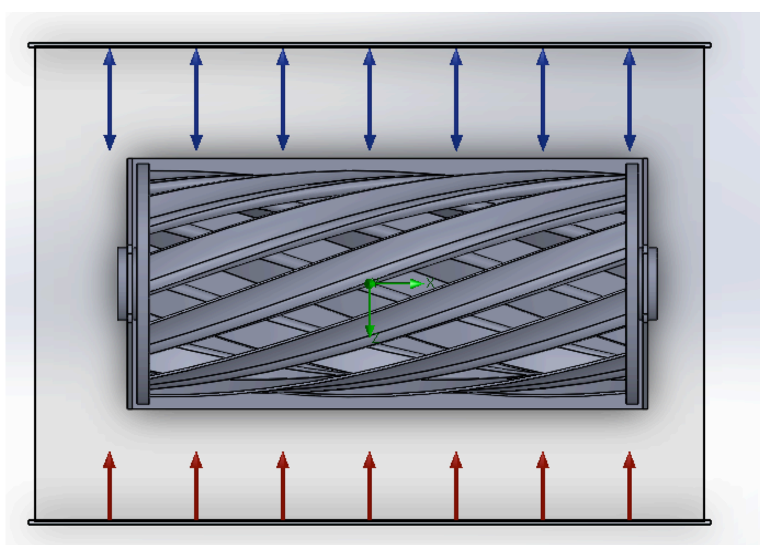


Fig 7.4: Boundary conditions for HAWT model

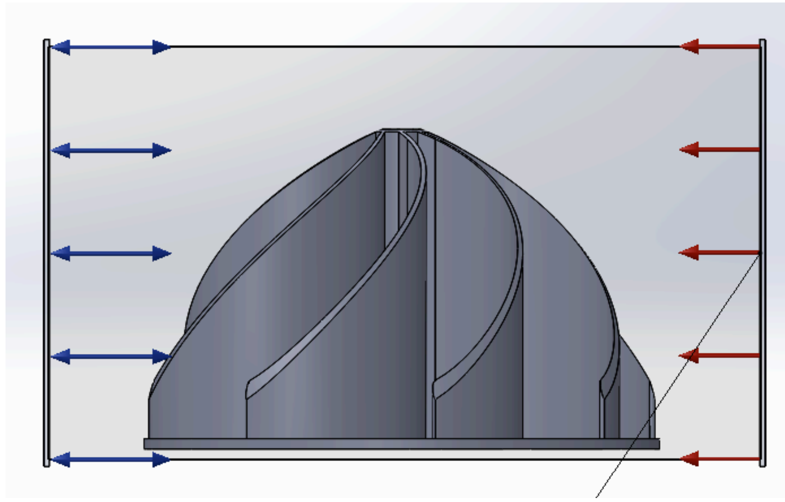


Fig 7.5: Boundary conditions for VAWT model

3. Charts and flow trajectory:

VELOCITY FLOW TRAJECTORIES:

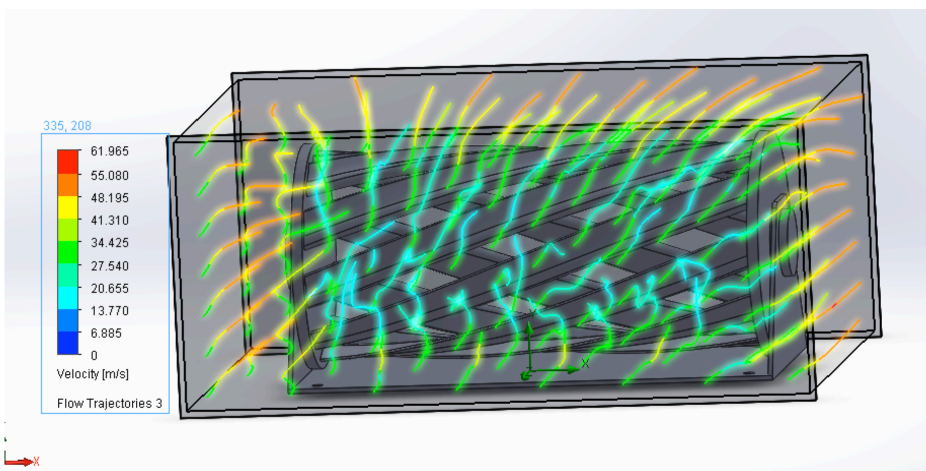


Fig 7.6: Velocity Flow Trajectories for HAWT

The detailed examination of the above flow trajectory plot provides us the condition that the flow of wind is equally distributed to both the upward and downward directions which would result in a self locking of the turbine and hence no power can be generated.

The above design is not considered any further.

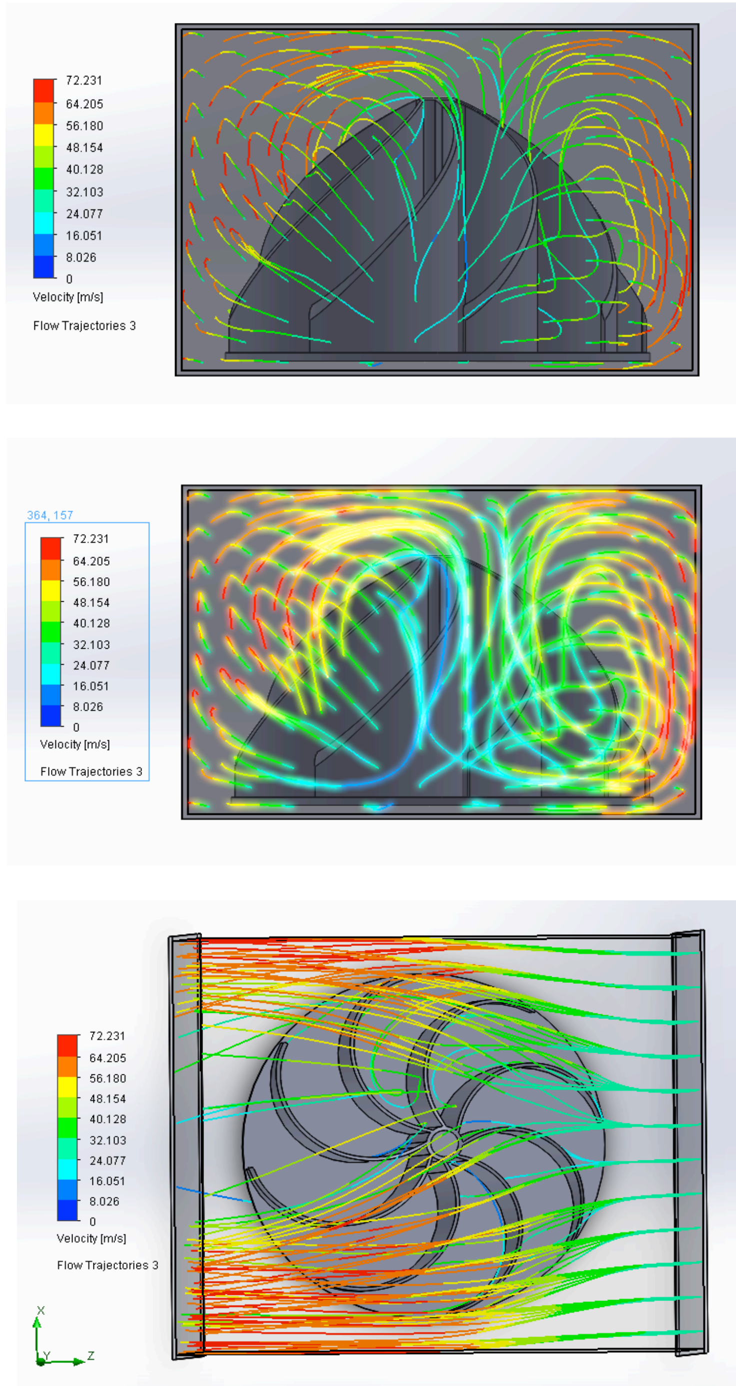


Fig 7.7: Velocity Flow Trajectories for VAWT

The plot shows that the flow of wind from the train through the tunnel impinging on the blades of the wind turbine tends to move over the curving profile of the blades towards the central shaft depicting that the wind will cause the motion to be set in the turbine. It can be observed that the color of the lines are changing along the wind turbine generally reducing in its value from the inlet towards the outlet also providing idea that the energy is being consumed by the turbine and it is set into motion.

PRESSURE FLOW TRAJECTORIES:

From the Pressure Flow Trajectory diagram it can be observed that the pressure across the turbine is gradually increasing and then decreasing along the inlet and outlet sides. Since the values are not very significantly different from the inlet and outlet sides, we can consider that the turbine is in safe working condition for the given velocity of wind.

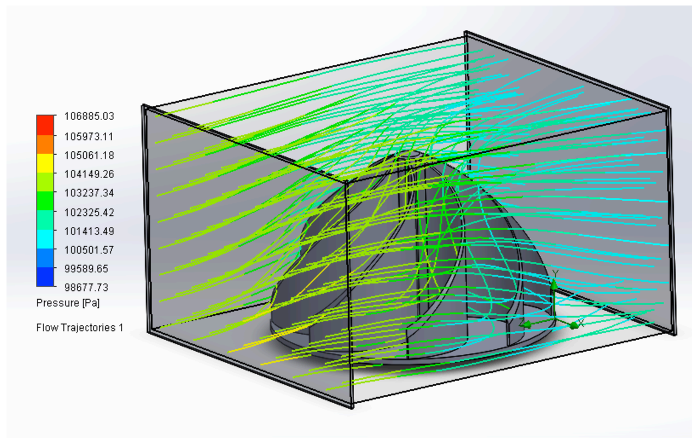


Fig 7.8: Pressure Flow Trajectories for VAWT

TEMPERATURE FLOW TRAJECTORIES:

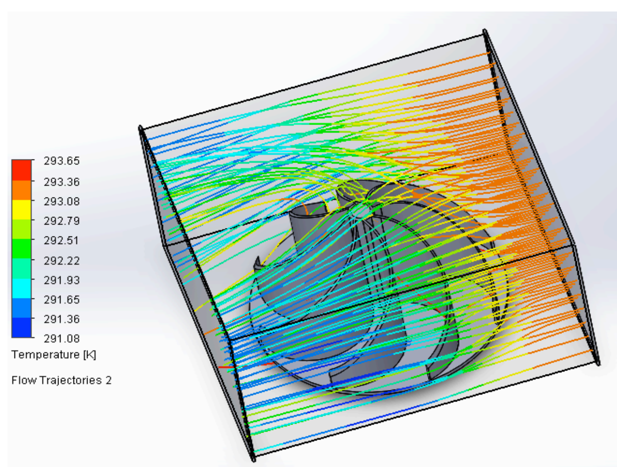
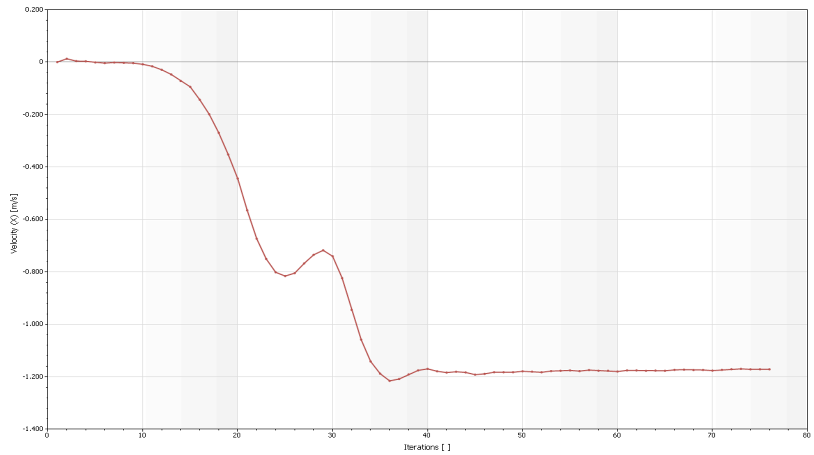


Fig 7.9: Temperature Flow Trajectories for VAWT

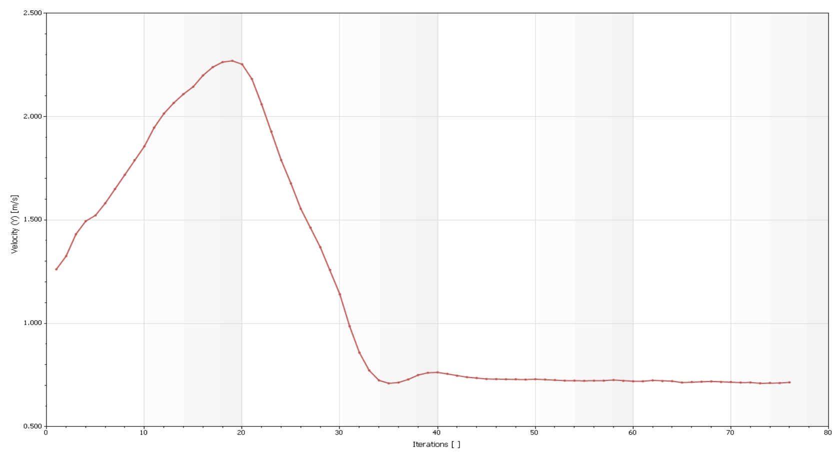
The flow lines with respect to the Temperature shows a slight increase in temperature at the outlet of the turbine. Since the value is not very high, by choosing the material of the turbine wisely, safe working of the turbine can be easily obtained.

4. Graphical representation of Flow Simulation Results:

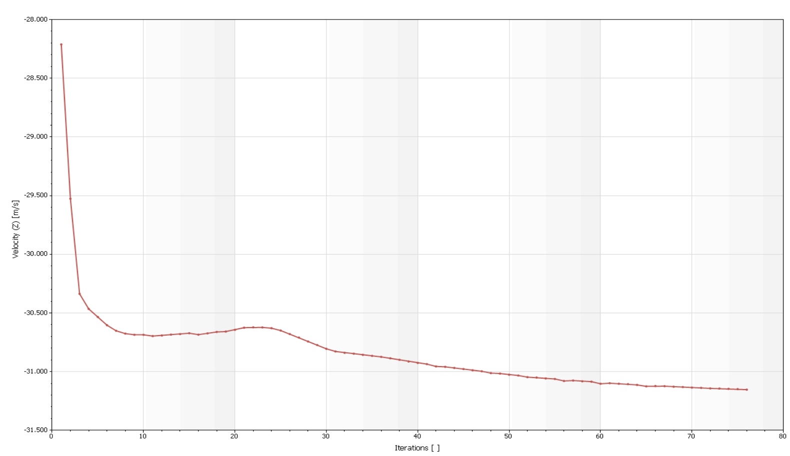
<u>VELOCITY:</u>



Velocity in direction - X

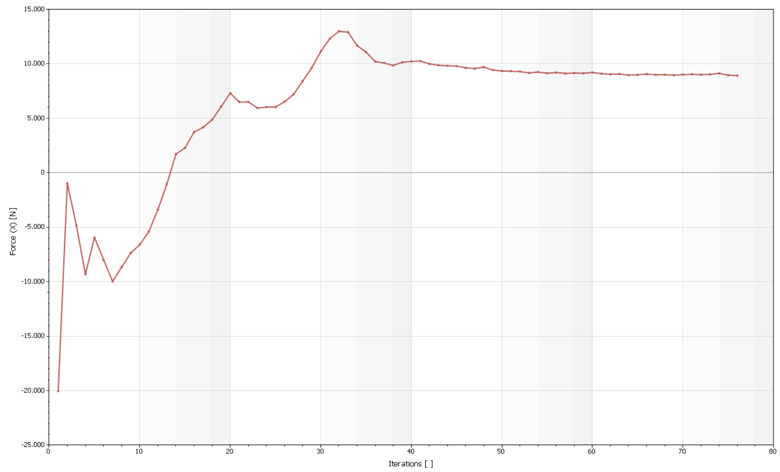


Velocity in direction - Y

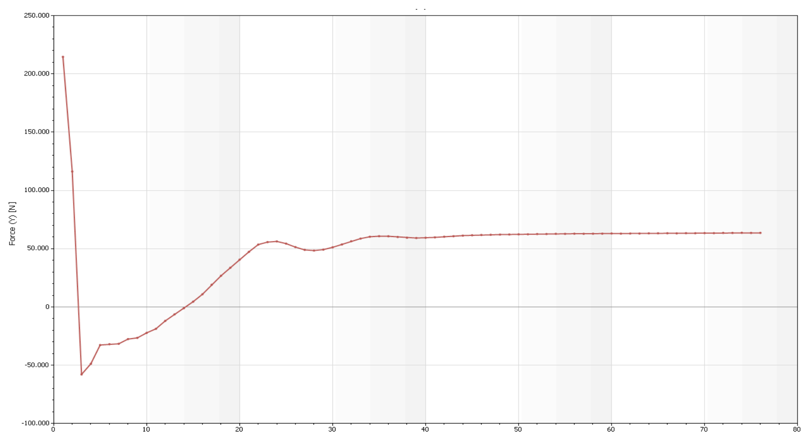


Velocity in direction – Z

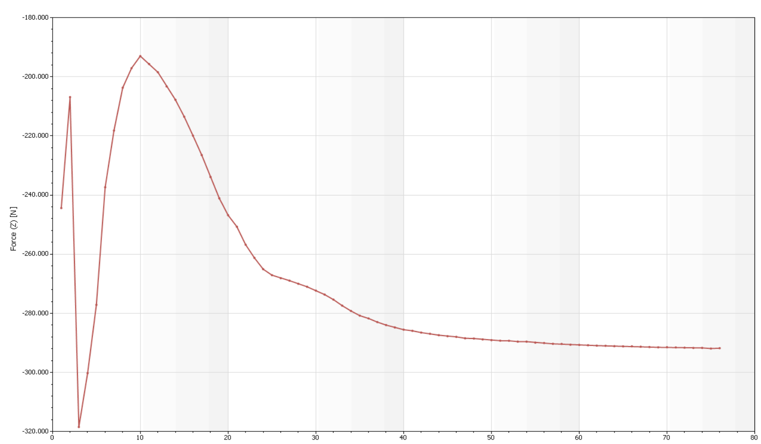
FORCE:



Force in direction – X

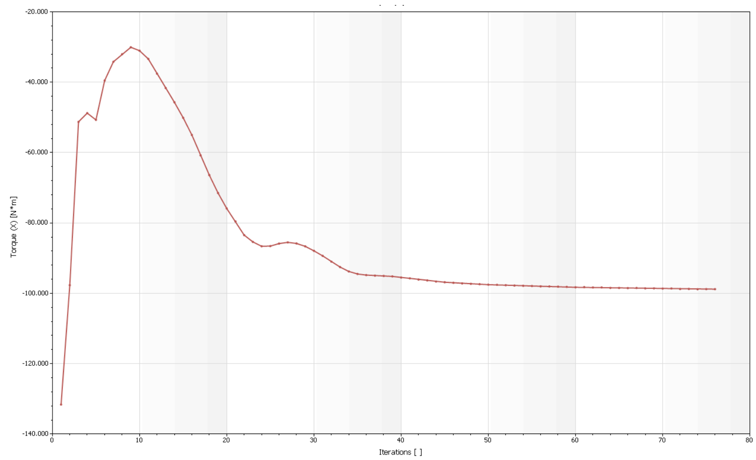


Force in direction – Y

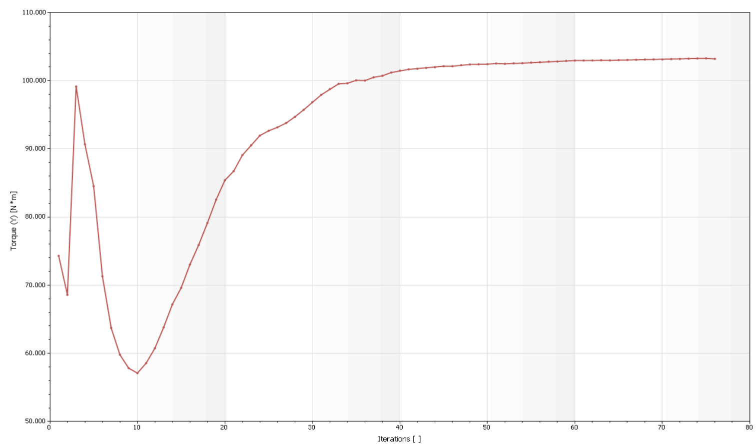


Force in direction – Z

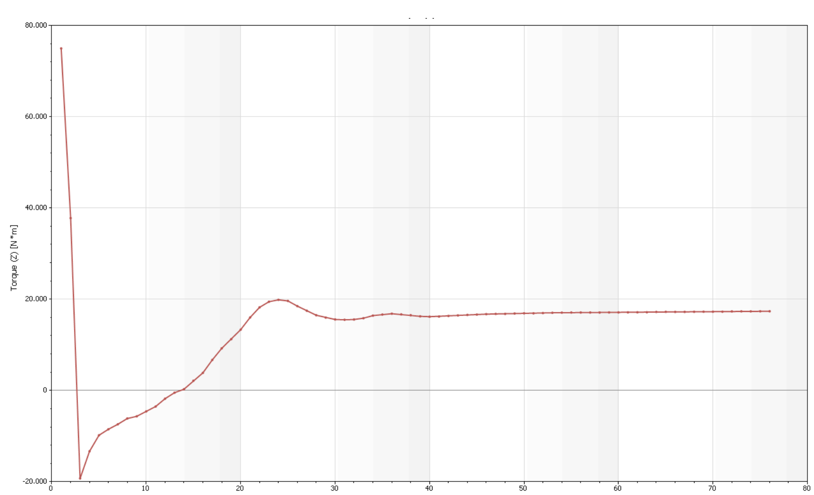
TORQUE:



Torque in direction – X



Torque in direction – Y



Torque in direction – Z

EXCEL DATA SHEET: Attached in the end

7.2 THEORETICAL CALCULATION FOR POWER OUTPOT OF TRAIN TOP MODEL:

CONSIDER THE MAX WIND POWER IS GIVEN AS:

$$W_{Tmax} = \frac{1}{2}\rho A V_{\infty}^{3} \cdot$$

C_P =0.59 for ideal turbine

Considering the following factors:

V_{∞}= 30 m/s

R= 0.25 m
A = 3.14. R^2
ρ=1.25 kg/m^3

W_{Tmax}= 3311.7 Watts
~ 3.3 kW

CHAPTER 8:

GENERAL FORMULAE FOR POWER PRODUCTION:

The kinetic energy of wind:

The kinetic energy of the wind is the source of the driving force of a wind turbine. That kinetic energy can be depicted by the formula. [16]

$$E = f.\ m_{spec}\ .v3$$

In this formula:

E = the kinetic energy

m_{spec} =the specific mass (weight) of air

v = the velocity of the moving air (the wind)

f = a calculating factor without any physic meaning

The power in the wind is proportional to:

- The area of windmill being swept by the wind.
- The cube of the wind speed.
- The air density - which varies with altitude.

The formula used for calculating the power in the wind is shown below:

Power = (density of air x swept area x velocity cubed)/2

$$\mathbf{P} = 1/2P(A)(V)\ 3$$

Where, **P** is power in watts (W)

P is the air density in kilograms per cubic meter (kg/m3)

A is the swept rotor area in square meters (m2) &

V is the wind speed in meters per second (m/s).

8.1 COST ECONOMICS:

However, the power output from the wind machine is proportional to cube of the wind speed and so the increase in wind speed will mean a significant increase in power and a subsequent reduction in unit costs. The output from the turbines is a factor proportional to the speed of the train and the time for which the train crosses the wind turbine. If the number of trains increases, then naturally the output multiplies in relation with the number of trains and hence leaves us with a profit in the long run.

8.2 ADVANTAGES:

There are some specially designed wind turbines. Traditionally wind turbines have three-blade, "open rotor" design.

A common method of this design is that even small turbines require a fast wind before they start operating. Small turbines can be used to generate more power and can be used for commercial applications as we store the retrieved energy in batteries.

The input wind energy is trust worthy source as it is directly related to the movement of the train.

Any quantity of output in this case is a profit as there is no input cost to run the turbine.

Only a small amount of investment and maintenance cost keeps us on the advantageous side.

CHAPTER 9:

CONCLUSION

There is an urgent need for transition from petroleum-based energy systems to one based on renewable resources to decrease reliance on depleting reserves of fossil fuels. An emphasis on presenting the real picture of massive renewable energy potential, it would be possible to attract foreign investments to herald a Green Energy Revolution in India. Reuse of human excreta and the composting of human and animal excreta and other organic waste are being used in cultivating plants and trees. Given technique provides generation of Green power. Free accessible energy can be created with the help of this work, which can cater to the growing demands of energy all around the world. The power which can be supplied by the battery can be used to light many powerless homes in the long run. Thus an alternate means of renewable energy is provided by this project, which will not only help solve the energy problems, but will also to an extent reduce the load on major sources of energy production like thermal power plants and nuclear power plants, which generally consume much of the treasured depleting resources. Therefore positive ramifications of this entire research are manifold and will tend to alleviate the major energy crisis problem faced all over the world.

- From the analytical formulae and calculations, it is evident that the **Power is directly proportional to the cube of velocity.** Hence the output is high.
- The proposed method helps in conserving the energy from train which otherwise is getting wasted.
- The **energy available is free** of cost and hence **any quantity of output is a profit**. (Unless considering the manufacturing and se up costs)
- The designs proposed **work in both directions** of travel of train.
- The output shaft can be connected to a gearbox to amplify the rotational speed for better generation of free energy.
- It is completely environmental friendly concept.
- Helps in providing a better earth for the future generations.

CHAPTER 10:

REFERENCES

1) M. REKHI, BHUPENDAR SINGH, "*A Method for Generating Electricity by Winds*", WIPO Patent Application WO/2009/093265, July 30, 2009.

2) S. BHARATHI, "*An Approach to Electricity Generation from Vehicles",* International Joint Journal Conference on Engg. & Tech Vol.1, 2010.

3) J. SKEA, "*The renaissance of energy innovation*", Energy & Environmental Science 7 (2014) 21-24

4) STEPHANE SANQUER, CHRISTIAN BARRE, MARC DUFRESNE DE VIREL and LOUIS-MARIE CLEON, "*Effect of cross winds on high-speed trains: development of new experimental methodology*", Journal of Wind Engineering and Industrial Aerodynamics, 92(2004), 535-545. (2004)

5) WILSON. R.E. and LISSAMAN. P.B.S., "*Applied Aerodynamics of Wind Power Machines*", Oregon State University, NTIS PB 238594 (1974).

6) KOSTYANTYN PROTSENKO, DEWEI XU. "*Modeling And Control of Brushless Doubly-Fed Induction Generators in Wind Energy Applications*" [J].IEEE Trans. On Power Electronics, 23(3) : 1191-1197. (2008)

7) JOHAN MRREN, SJOERD, W.H.FE HAAN, "*Ride through of Wind Turbines with Doubly fed Induction Generator during a Voltage Dip*". [J].IEEE Transactions on energy conversion , Vol.20,No.1,Page(s):435-441.

8) YULONG WANG, JIANLIN LI, SHUJU HU, HONGHUA XU. "Analysis on wind power system low voltage ".

9) A. AHMED, "*A novel small scale efficient wind turbine for power generation*", Renewable Energy 57 79-85. (2013)

10) A.S. BAHAJ, L. MYERSs, P.A.B. JAMES, *"Urban energy generation: Influence of micro-wind turbine output on electricity consumption in buildings",* Energy and Buildings, 39(2) (2007) 154-165

11) M. BORTOLINI, M. GAMBERI, A. GRAZIANI, R. MANZINI, F. PILATI, *"Performance and viability analysis of small wind turbines in the European Union".* Renewable Energy 62 (2014)

629-639

12) MD. ARIFUJJAMAN, M. TARIQ IQBAL, JOHN E. QUAICOE, *"Energy capture by a small wind energy conversion system", Applied* Energy 85 (2008) 41–51

13) MENAKA. S, ARCHANA ADARSH RAO. "*Production of Electricity using the Wind turbine Mounted on a Moving Vehicle"*

14) R. HOWELL, N. QIN, J. EDWARDS, N. DURRANI, *"Wind tunnel and numerical study of a small vertical axis wind turbine"*, Renewable Energy 35 (2010) 412-422

15) G.M.J. HERBERT, S. INIYAN, E. SREEVALSAN, S. RAJAPANDIAN, *"A review of wind energy technologies"*, Renewable and Sustainable Energy Reviews 11 (2007) 1117–1145

16) H. HIRAHARA, M. Z. HOSSAINB, M. KAWAHASHIA, Y. NONOMURA, "*Testing basic performance of a very small wind turbine designed for multi-purposes",* Renewable Energy 30 (2005) 1279– 1297

17) C.J. BAKER, "*Train Aerodynamic Forces and Moments from Moving Model Experiments*", Journal of Wind Engineering and Industrial Aerodynamics, 24(1986), 227-251.