DESIGN AND MANUFACTURING OF A TULIP TYPE WIND TURBINE TO HARVEST ELECTRICAL ENERGY

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January 2023

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A thesis submitted to the Department of Mechanical Engineering, Sonargaon University, Dhaka, in January, 2023 in partial fulfilment of the requirements for the degree of Bachelor of Science in Mechanical Engineering.

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Abstract

Renewable energy sources is the best option to alternate the existing power generation process of the today's world. Generating energy that produce no green house gas emission from fossil fuels and reduce reference air pollution, Diversifying energy supply and reducing dependence on imported fuels we need to create economic development by utilizing renewable energy sources.

It's targeted by us to produce cheap electricity from renewable energy sources and provide 65% of world's total electricity supply by 2030. Which could be decarbonized 90% of the power sector by 2050, massively cutting carbon emission and helping to migrate climate change.

In our project we have tried to build up a tulip type portable wind turbine and by this generate power and implement it by load needed.

List of Figures

Sl.	Significant of Figures	Page no.
1	Block Diagram	15
2	Circuit diagram (A)	15
3	Circuit diagram (B)	16
4	Circuit diagram (C)	16
5	Base plate	21
6	Frame	21
7	Foundation (A), (B)	22
8	Tulip designed blade	23
9	Spur gear arrangement	23
10	Working of DC Generator	24
11	IR sensor	27
12	ACS712	28
13	Arduino Nano programming	29
14	Arduino Nano Board	32
15	Arduino Nano Pinout	33
16	Monitor	34
17	Working with wind flow.	37
18	Wind flow direction	37
19	Positive & Negative wind effect with graphs.	38
20	Wind flow direction	44

List of Tables

Sl.	Significant of Table	Page no.
1	List of equipments	22
2	Performance chart (A)	38
3	Increasing output according to wind speed.	39
4	Performance chart (B)	39
5	Performance chart (C)	39

List of Contents

Sl	Chapter	Topic	Page
01	Front page	-	01
02	Inner front page	-	02
03	Abstract	-	03
04	List of Figures	-	04
05	List of Tables	-	05
06	List of Contents	-	06
07	Chapter One Introduction	1.1 Introduction	09
		1.2 Background study	10
		1.3 Problem statement	10
		1.4 Aim and Objects	12
		1.5 Thesis outlines	12
08	Chapter Two Literature reviews	2.1 Introduction	14
		2.2 Previous works and how they performed.	17
		2.3 Conclusion	17
09	Chapter Three Methodology	3.1 Introduction	20
		3.2 Setup description	21
		3.3 Working principle and Data Collection procedure.	34
		3.4 Conclusion	35

10	Chapter Four Result analysis	4.1 Introduction	37
		4.2 Data and Graph	37
		4.3 Result analysis	38
		4.4 Conclusion	40
11	Chapter Five Conclusion and Recommandations	5.1 Introduction	42
		5.2 Limitations	42
		5.3 Future scopes	43
		5.4 Conclusion	43
12	Chapter Six References	-	46

Chapter One

Introduction

1.1 Introduction:

Wind power is the process of harnessing energy from the movement of the wind and converting it to useful forms of mechanical power and electricity.

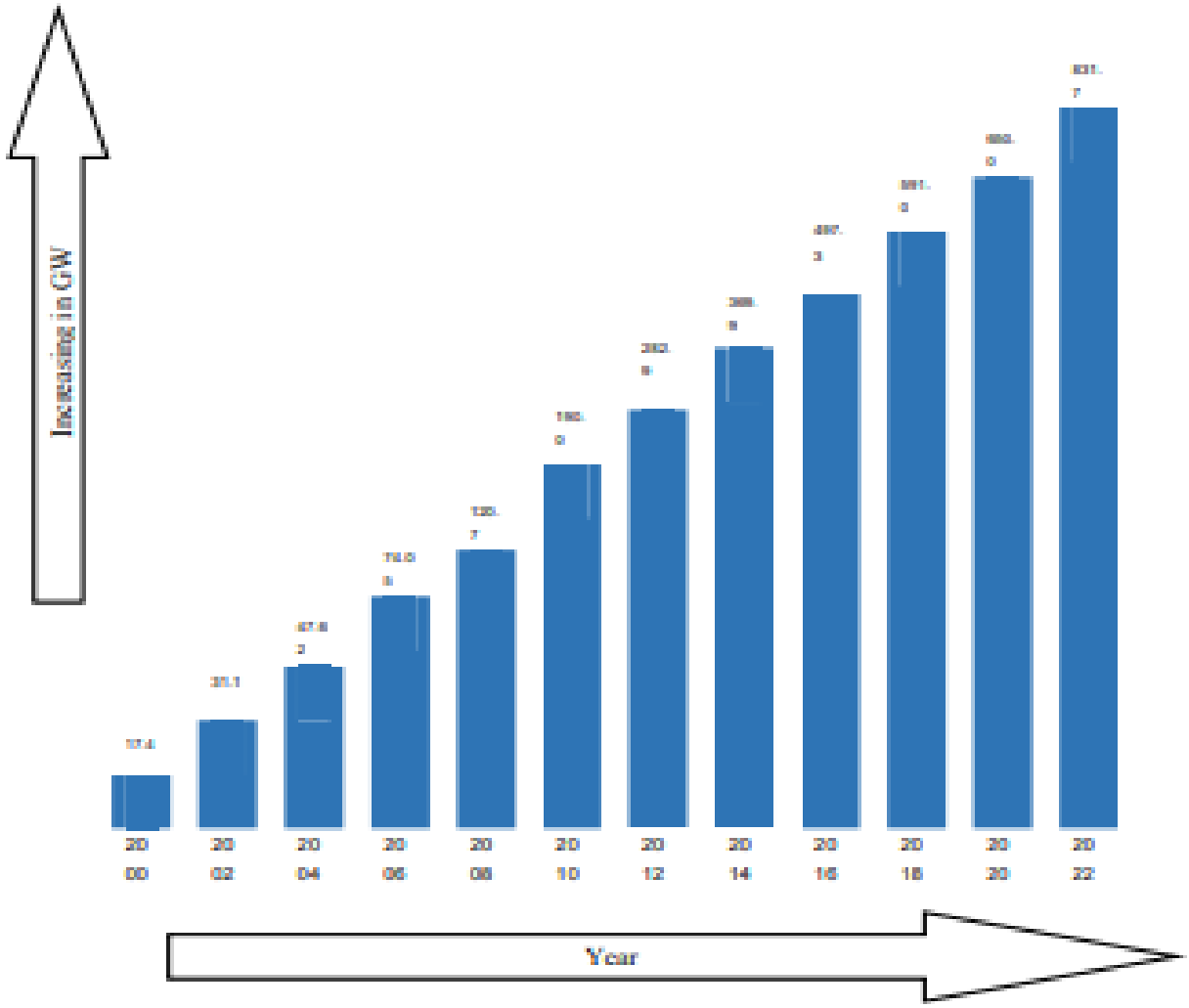


Fig : Wind energy aspect increasing

Today wind power one of the most popular renewable energy source and the experts believe that by 2050 wind energy could be the solution to one third world's total electricity requirement. The growth of using wind power is given below:

1.2 Background study:

A device that converts the kinetic energy of wind into electrical energy may called as wind turbine. As of 2020 hundred of thousands of large turbines in installation as known as wind firms generating over 700 gigawatts of power with 60 gigawatts adding per year.

Tulip Type wind Turbines makes innovative vertical axis turbines to help you solve the energy crisis and own your electricity. Flower Turbines' tulip design offers a unique combination of beauty & power. Tulip Type wind Turbines produces small, vertical windmills in the shape of a tulip. The windmills are quiet, efficient and take up little space. Per square metre, the turbines generate more energy than solar panels when there is sufficient wind. The rated power of Flower Turbines 3-Meter Model is 100 kW.

1.3 Problem statement:

In this project we'll try to build up a tulip type wind turbine and try to harvest energy by this.

What to do:

We'll form a structure of wind turbine shaped like a tulip and use it to harvest energy from it. We'll build a stainless steel structure with a tube shaft in the centre of it.

Why to do:

Perhaps a gentle reserve of fossil fuel is existing in the earth but its usage is increasing alarmingly day by day and the dependence on the fuel is increasing much. At the same time the reserve is decreasing as the production of the fuel is not possible so we've to think about the alternate way with renewable energy sources. In this project we'll try to harvest energy with a wind turbine which will provide us a clean and non-carbon producing power supply by using the wind energy. By preferring renewable energy with thought about wind power as it is friendly for the environment. Tulip type wind turbine is a kind of vertical axis turbines. Tulip design offers a unique combination of beauty and power. These are produces small vertical turbines which are queit, efficient and take a little space. It is more efficient than solar panelsif the wind is provided sufficiently.

How to do:

In this project we'll implement our theory which studied. We'll build a stainless steel structure with a tube shaft in the centre of it. The shaft will be engaged with another shaft by spur gears which hold a generator at the end of it. A tulip type fan arrangement which can rotate with the wind pressure will operate the driving shaft and the spur gear arrangement enhance its RPM and provide to generator. When the generator shaft rotates voltage creates in it.

1.4 Aim and Objectives:

The objectives of the project are

- To study about wind turbine and its power generation process.
- To construct and assemble a portable wind turbine to implement our idea on it.
- To test the efficiency by increasing and decreasing the working diameter of the blades of the frame.
- To find the drawback and limitation of the project and rectify to make it more efficient.

1.5 Thesis outlines:

At the end of the project our targets are

- To prepare a tulip wind turbine practically.
- To generate and harvest power by the turbine.
- To use the power with a resistive load to show the result.
- To find the problems and drawbacks of the project and try to rectify them to make the project more efficient.
- To know how a tulip wind turbine works at the variable diameter of blade and the harvesting ratio due to it.

Chapter Two

Literature Review

2.1 Introduction:

Renewable energy experts believe that by 2050 wind energy could be the solution to one third of world’s electricity requirement. Which could decarbonize 90% of power sector with massively cutting carbon emission and helping to migrate climate change. In our project we have tried to build up a tulip type portable wind turbine and by this power generate and utilize.

Wind enters the turbines and then hits both blades at the same time. The horizontal ribs reduce turbulence and increase efficiency. This allows the turbines to produce more energy from a lower wind speed.” The turbines can be installed almost anywhere the wind exists, even at a lower speed.

Wind turbines use blades to collect the wind's kinetic energy. Wind flows over the blades creating lift (similar to the effect on airplane wings), which causes the blades to turn. The blades are connected to a drive shaft that turns an electric generator, which produces (generates) electricity.

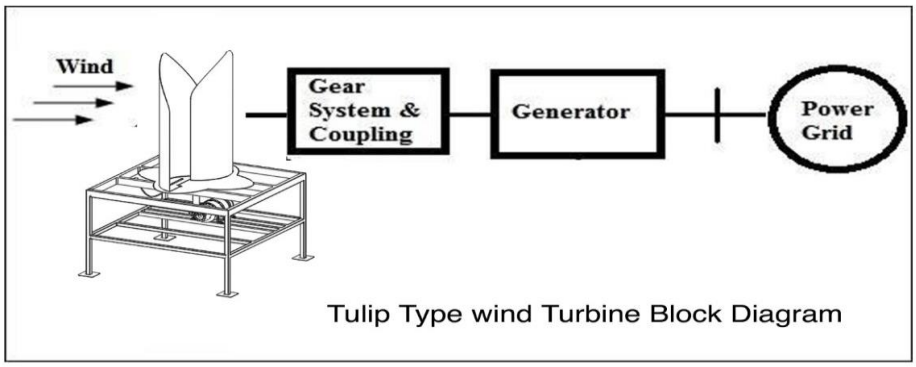


Fig. Block Diagram

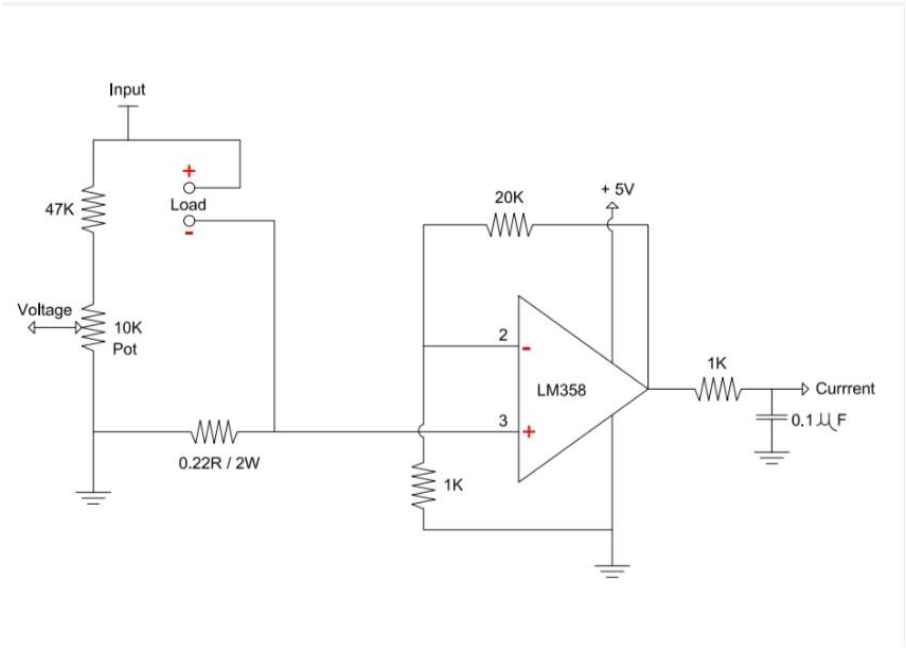


Fig: Circuit diagram (A)

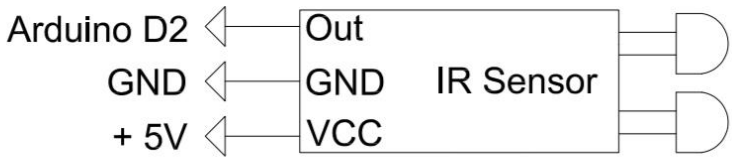


Fig: Circuit diagram (B)

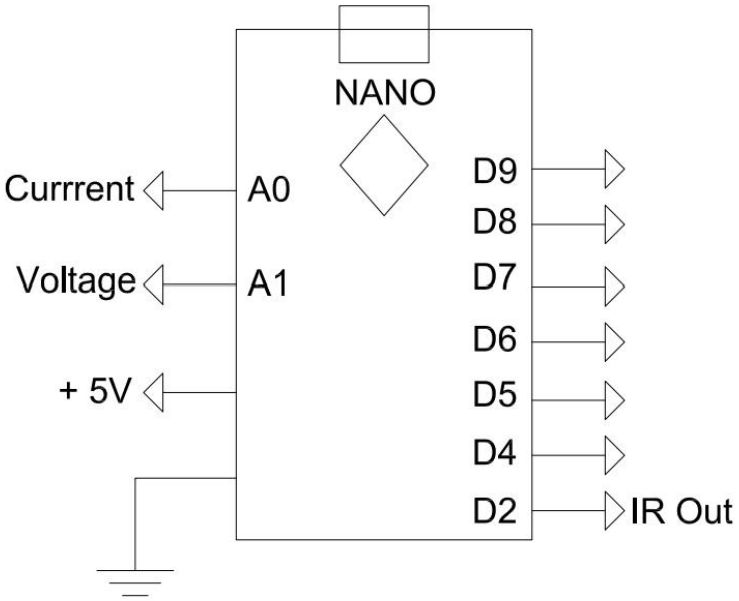


Fig: Circuit Diagram (C)

2.2 Previous work & how they performed:

A small model research VAWT turbine has been manufactured as prototype and tested over a range of operating conditions. The straight turbine rotor blade, with an aspect ratio of 4:1, operates at relatively low tip speeds and its performance shows a clear dependence on the rotor blade surface finish. Below a critical Reynolds number (30,000), the performance is enhanced by having the surface of the turbine roughened, but above this Reynolds number the power coefficient is observed to be degraded. Computational predictions of the performance coefficient of this turbine were carried out and the 3D simulations were shown to be in reasonably good agreement with the experimental measurements, considering errors and uncertainties in both the CFD simulations and the wind tunnel measurements. The 2D simulations of flow showed a significantly increased

Performance compared to the 3D simulations and this was shown to be mainly due to the presence of the large tip vortices present in the real turbine and the 3D simulations. Simulations illustrated the periodic pulsing nature of the tip vortices caused by the changing lift generated by the rotor blades as they travel through each rotor revolution. At phases considered where higher amounts of lift are generated, stronger tip vortices are present, whereas at phases where little lift is generated, the vortices are observed to be significantly reduced as per work carried out.

2.3 Conclusion:

Vertical axis wind turbine offer economically viable energy solution for remote areas away from theIntegrated electricity grid systems. Blade design plays critical role for performance and energy extraction

from turbine. In order to spread the use of VAWT, the problems associated with various configurations, i.e. poor self-starting and low initial torque, low coefficient of power, poor building integration should be overcome. With the assumption of placing the turbine in a location with moderate wind availability with optimized blade parameters and design specifications, high power generation is achieved with vertical axis wind turbine and can be serving as energy generation unit for remote areas.

Chapter Three

Methodology

3.1 Introduction:

Global energy consumption in the last half centuryhas increased very rapidly and is expected to continueto grow over the next 50 years. However, significant changes are now expected. The past increase rate was stimulated by relatively cheap fossil fuels supporting industrialization in North America, Europe, and Japan. While energy consumption in these countries continues to increase, additional factors are making the picture more complex. It is unclear yet how the required electricity production will be covered. Many developed and developing countries have realized the importance of wind as an important resource for power generation. Necessary measuresare being taken up across the globe to tap this energy for an effective utilization. From an emerging energy source twenty years ago, wind energy has evolved into a mature and booming global business. Associated costs have fallen dramatically over the last 15 years, moving closer to those of conventional energy sources. However, even if the associated technology has been greatly improved during the last decade, the available technical design is not yet adequate to develop reliable wind energy converters for low wind-speeds, reduced inter-turbine spacings and urban environment. Vertical-axis turbines like the tulip type turbine may be suitable converters for such conditions. The tulip type initially developed the vertical-axis Tulip type rotor in the late 1920s. The concept of the conventional rotor is based on cutting a cylinder into two halves along the central plane and then moving the two half cylinders sideways along the cutting plane, so that the cross-section resembles the tulip type rotor, which is a slow-running vertical axis wind machine, has a rather poor efficiency: Cp =

0.2 [1] at best. Nevertheless, it can present some advantages for specific applications, in particular due to its simplicity, resulting robustness and low costs. If a sufficient efficiency could be obtained, the tulip type rotor would become a very interesting complementary source of electricity from wind energy.

3.2 Setup & Description:

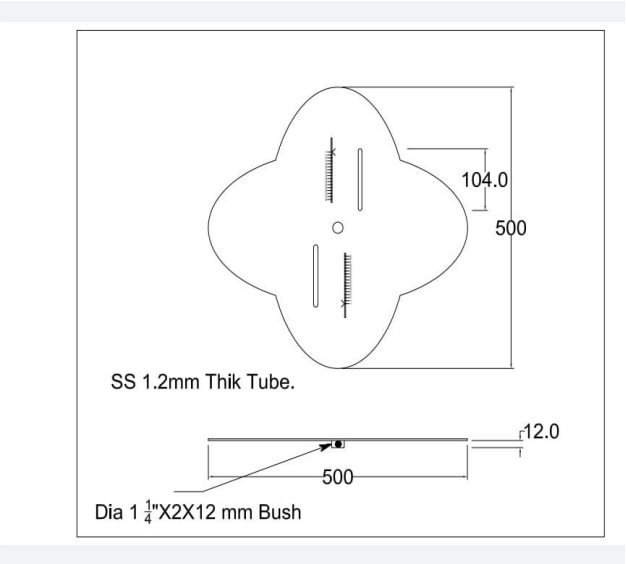


Fig: Base plate

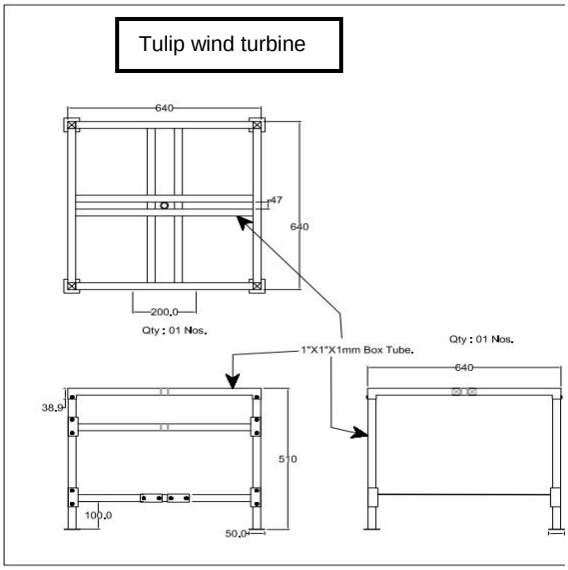


Fig: Frame

Setup:

The project based on a stainless steel (grade 201) structure frame which holds a stainless steel sheet on it. The sheet centred with a tube shaft which holds a nylon spur gear and two bearings which works as an energy converter (kinetic to electrical) by the blades with the help of wind flow. A generator mounted with another shaft which is connected by the tube shaft with a spur gear. During rotating the gear amplify the rotation speed and generate a gentle RPM which is enough to produce electricity by the generator. An electrical sensor device

helps to display unit to show the RPM, voltage and output respectively.

Table: List of equipments

Sl	Name	Spacification	Size	Qty	Unit
1	Turbine Blade	0.6mm Sheet	Dia 250X H-420mm	2	Pcs
2	Blade Base Holder	1.5mm SS Sheet	250X90X1.5mm	2	Pcs
3	Turbine Base	1.5mm SS Sheet	500X500X1.5mm	1	Pcs
4	Shaft Tube	Dia 25.4X1.2mm	715mm	1	Pcs
5	Main Structure	1"X1"X1mm Tube	640X640X510mm	1	Set
6	Gear-1	Nylon Spur Gear	Dia 175mm	1	Pcs
7	Gear-2	Nylon Spur Gear	Dia 26mm	1	Pcs
8	Bearing	6205-2Z/C3	Internal Dia 1"	2	Pcs
9	DC Motor/Generator	12V DC		1	Pcs
10	Base Plate	2mm Thik SS Sheet	50X50X2mm	4	Pcs
11	Bush	Dia 40mm	40mm	1	Pcs

Project Images:

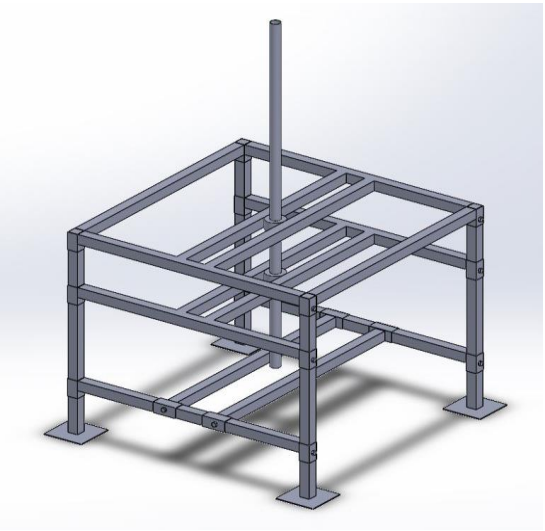


Fig: Foundation (A)



Fig: Foundation (B)



Fig: Tulip designed blade



Fig: Spur gear arrangement

Description:

12 V DC Generator:

A DC generator is an electrical machine whose main function is to convert mechanical energy into electricity. When the conductor slashes magnetic flux, an emf will be generated based on the **electromagnetic induction principle of Faraday's Laws**.

An electric generator is an electrical machine which converts electrical energy into mechanical energy. The basic **working principle of a DC generator** is: "*whenever a current carrying conductor is placed in a magnetic field, it experiences a mechanical force".* The direction of this force is given by Fleming's left-hand rule and its magnitude is given by F = BIL. Where, B = magnetic flux density, I = current and L = length of the conductor within the magnetic field.

Fleming's left hand rule: If we stretch the first finger, second finger and thumb of our left hand to be perpendicular to each other, and the direction of magnetic field is represented by the first finger, direction of the current is represented by the second finger, then the thumb

represents direction of the force experienced by the current carrying conductor.

Working principle of a DC generator

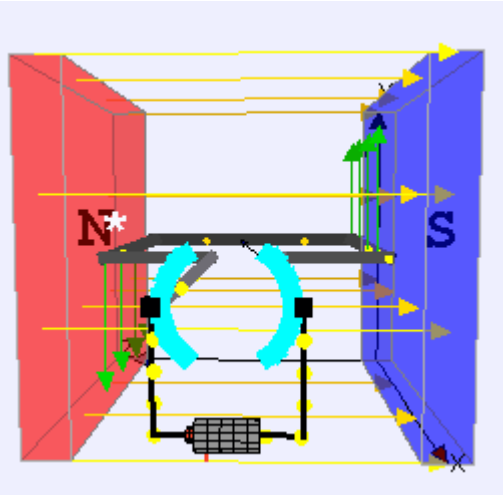


Fig: Working of DC Generator

Above animation helps in understanding the **working principle of a DC generator**. When armature windings are connected to a DC supply, an electric current sets up in the winding. Magnetic field may be provided by field winding (electromagnetism) or by using permanent magnets. In this case, current carrying armature conductors experience a force due to the magnetic field, according to the principle stated above.

Commutator is made segmented to achieve unidirectional torque. Otherwise, the direction of force would have reversed every time when the direction of movement of conductor is reversed in the magnetic field. **This is how a DC generator works**!

Application of DC Series generator

DC series generator is suitable for both high and low power drives, for fixed and variable speed electric drives. This type of generator has simple construction. Also, it is easy for design and maintenance.

Because of its high starting torque, this generator uses in the cheap toys and automotive applications such as,

- Cranes
- Air compressor
- Lifts
- Elevators
- Winching system
- Electric traction
- Hair drier
- Vacuum cleaner and in speed regulation application
- power tools
- Sewing machine
- Electric footing

Application of DC Shunt generator

We all know that Dc shunt generator provides the constant speed. This type of generator mostly uses in the constant speed application from no load to full load. The applications are,

- Wiper
- Automatic windscreen
- Drills
- Conveyors
- Fans

- Boring mills
- Shapers
- Blowers
- Spinning and weighing machine
- Centrifugal pumps

SKF 6205-2Z/C3 Bearing:

Deep groove ball bearing with seals or shields
Single row deep groove ball bearings with seals or shields are particularly versatile, have low friction and are optimized for low noise and low vibration, which enables high rotational speeds. They accommodate radial and axial loads in both directions, are easy to mount, and require less maintenance than many other bearing types. The integral sealing can significantly prolong bearing service life because it keeps lubricant in the bearings and contaminants out.

- Integral sealing prolongs bearing service life
- Simple, versatile and robust design
- Low friction and high-speed capability
- Accommodate radial and axial loads in both directions
- Require little maintenance

Nylon Spur Gears:

Here we have used to nylon spur gears to enhance the shaft RPM to provide to the generator. The gears have 23 and 116 teeths respectively. Which can enhance the rotation five times more in driven shaft.

Sensors & working principles:

IR Sensor

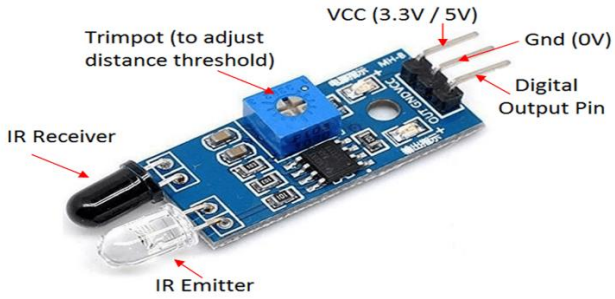


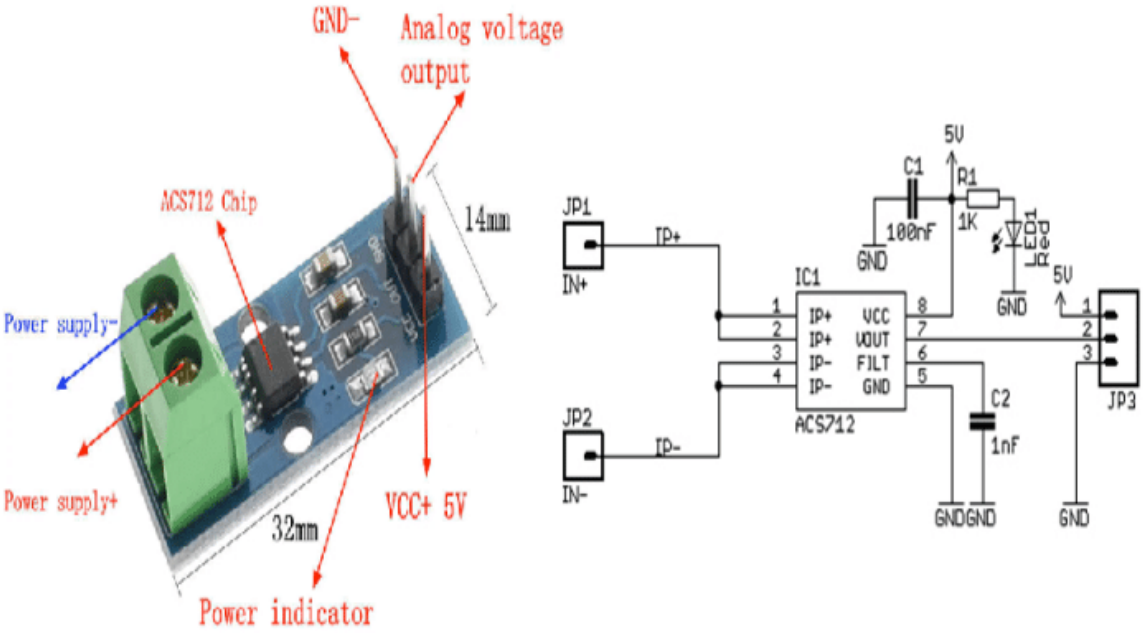
Fig: IR Sensor

IR sensor is an electronic device that emits the light in order to sense some object of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. Usually, in the infrared spectrum, all the objects radiate some form of thermal radiation. These types of radiations are invisible to our eyes, but infrared sensor can detect these radiations.

The emitter is simply an IR LED (Light Emitting Diode) and the detector is simply an IR photodiode. Photodiode is sensitive to IR light of the same wavelength which is emitted by the IR LED. When IR light falls on the photodiode, the resistances and the output voltages will change in proportion to the magnitude of the IR light received.

ACS712

The ACS712 is a fully integrated, hall effect-based linear current sensor with 2.1kVRMS voltage isolation and an integrated low-resistance current conductor. Technical terms aside, it’s simply put forth as a current sensor that uses its conductor to calculate and measure the amount of current applied



For current sensors that work by direct sensing, ohm's law is being applied to measure the drop in voltage when flowing current is detected

ACS712 Current Sensor Applications

We've established a general idea of what current sensors are applicable for earlier. Well, with the ACS712 IC being able to detect both AC/DC current, it can be used in a wider range of applications apart from electrical appliances. Be it Arduino/other microcontroller usages, or industrial, commercial, and communication applications, it can be found applicable.

Here are the common list of applications:

- Generator speed control in generator control circuits
- Electrical load detection and management
- Switched-mode power supplies (SMPS)
- Protection for over-current

Arduino Nano programming

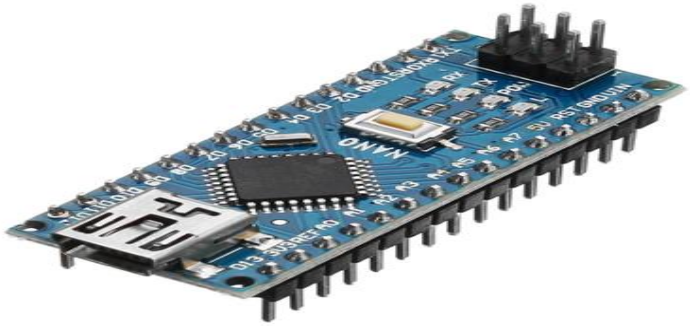


Fig: Arduino Nano programming

Arduino Nano is one type of microcontroller board, and it is designed by Arduino.cc. It can be built with a microcontroller like Atmega328. This microcontroller is also used in Arduino UNO. It is a small size board and also flexible with a wide variety of applications. Other Arduino boards mainly include Arduino Mega, Arduino Pro Mini, Arduino UNO, Arduino YUN, Arduino Lilypad, Arduino Leonardo, and Arduino Due. And other development boards are AVR Development Board, PIC Development Board, Raspberry Pi, Intel Edison, MSP430 Launchpad, and ESP32 board.

This board has many functions and features like an Arduino Due Milanovic board. However, this Nano board is different in packaging. It doesn’t have any DC jack so that the power supply can be given using a small USB port otherwise straightly connected to the pins like VCC & GND. This board can be supplied with 6 to 20volts using a mini USB port on the board.

Arduino nano:

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This board has many functions and features like an Arduino Duemilanove board. However, this Nano board is different in packaging. It doesn't have any DC jack so that the power supply can be given using a small USB port otherwise straightly connected to the pins like VCC & GND. This board can be supplied with 6 to 20volts using a mini USB port on the board.

Arduino Nano Programming

The programming of an Arduino nano can be done using the Arduino software. Click the Tools option and select the nano board. Microcontroller ATmega328 over the Nano board comes with preprogrammed with a boot loader. This boot loader lets to upload new code without using an exterior hardware programmer. The communication of this can be done with the STK500 protocol. Here the boot loader can also be avoided & the microcontroller program can be done using the header of in-circuit serial programming or ICSP with an Arduino ISP.

Applications of Arduino Nano

These boards are used to build Arduino Nano projects by reading inputs of a sensor, a button, or a finger and gives an output by turning generator or LED ON, or and some of the applications are listed below.

- Samples of electronic systems & products
- Automation
- Several DIY projects
- Control Systems
- Embedded Systems
- Robotics
- Instrumentation

Power Pin (VIN, 3.3V, 5V, GND): These pins are power pins

- VIN is the input voltage of the board, and it is used when an external power source is used from 7V to 12V.
- 5V is the regulated power supply voltage of the nano board and it is used to give the supply to the board as well as components.
- 3.3V is the minimum voltage which is generated from the voltage regulator on the board.
- GND is the ground pin of the board

RST Pin (Reset): This pin is used to reset the microcontroller

Analog Pins (A0-A7): These pins are used to calculate the analog voltage of the board within the range of 0V to 5V

I/O Pins (Digital Pins from D0 – D13): These pins are used as an i/p otherwise o/p pins. 0V & 5V

Serial Pins (Tx, Rx): These pins are used to transmit & receive TTL serial data.

External Interrupts (2, 3): These pins are used to activate an interrupt.

PWM (3, 5, 6, 9, and 11): These pins are used to provide 8-bit of PWM output.

SPI (10, 11, 12, & 13): These pins are used for supporting SPI communication.

Inbuilt LED (13): This pin is used to activate the LED.

IIC (A4, A5): These pins are used for supporting TWI communication.

AREF: This pin is used to give reference voltage to the input voltage

Arduino Nano Features

The features of an Arduino nano mainly include the following.

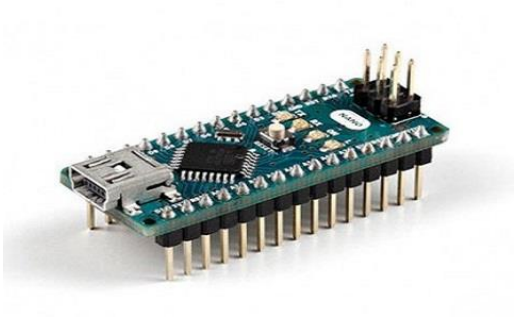


Fig: Arduino-nano-board

- ATmega328P Microcontroller is from 8-bit AVR family
- Operating voltage is 5V
- Input voltage (Vin) is 7V to 12V
- Input/Output Pins are 22
- Analog i/p pins are 6 from A0 to A5
- Digital pins are 14
- Power consumption is 19 mA
- I/O pins DC Current is 40 mA
- Flash memory is 32 KB

- SRAM is 2 KB
- EEPROM is 1 KB
- CLK speed is 16 MHz
- Weight-7g
- Size of the printed circuit board is 18 X 45mm
- Supports three communications like SPI, IIC, & USART

Arduino Nano Pinout

Arduino nano pin configuration is shown below and each pin functionality is discussed below

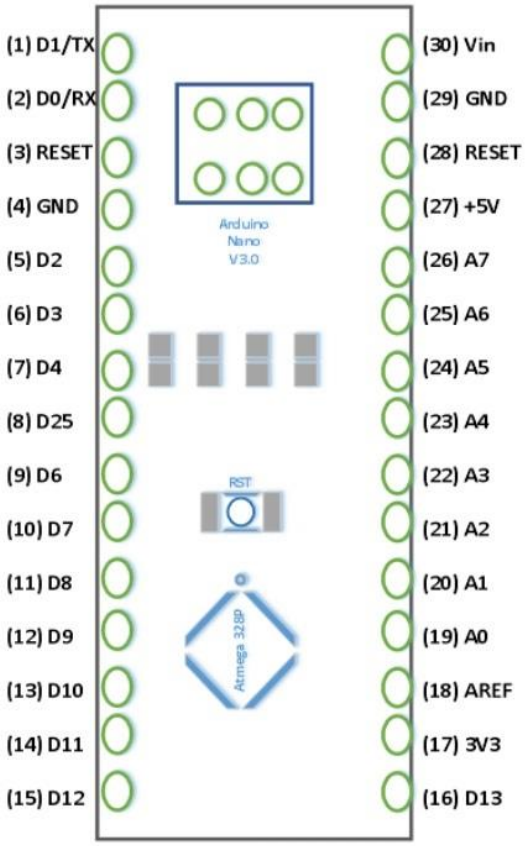


Fig: Arduino Nano Pinout

3.3 Working principle & data collection procedure:



Fig: Monitor

A liquid crystal display or LCD draws its definition from its name itself. It is a combination of two states of matter, the solid and the liquid. LCD uses a liquid crystal to produce a visible image. Liquid crystal displays are super-thin technology display screens that are generally used in laptop computer screens, TVs, cell phones, and portable video games. LCD's technologies allow displays to be much thinner when compared to a cathode ray tube (CRT) technology.

Liquid crystal display is composed of several layers which include two polarized panel filters and electrodes. LCD technology is used for displaying the image in a notebook or some other electronic devices like mini computers. Light is projected from a lens on a layer of liquid crystal. This combination of colored light with the grayscale image of the crystal (formed as electric current flows through the crystal) forms the colored image. This image is then displayed on the screen.

● COB with metal frame
● 5x7 dots with cursor
● Built-in controller RW1063
● +5V single power supply
● 1/16 duty cycle
● LED B/L pins:15/16,or A/K or 1/2
● Option: LED , EL B/L
● Option: +3V single power supply
● Option: Negative voltage
● 4-line SPI interface only

BC1604AR is 16x4 characters LCD Module (LCM) made using Chip on Board (COB) method and comes with metal frame.

Module dimension of BC1604AR is (87x60) mm and viewing area is (62x26) mm.

It has built-in controller RW1063 that provides different language options, English, Japanese, Western & Eastern European, Russian etc.

It is available with LED, EL backlight options, +3V single power supply option.

3.4 Conclusion

In this concluding chapter we've summarized our findings and argumnts and reflect back on some of the strength and weakness of the theoretical and methodological approaches we've taken.

Chapter Four

Result Analysis

4.1 Introduction:

In this chapter we'll summarize the results of the whole project and analyse the efficiency of the work we've done. Here the working process analyses are given in below and figures as we've implemented in various perceptions.

4.2 Data & Graphs:

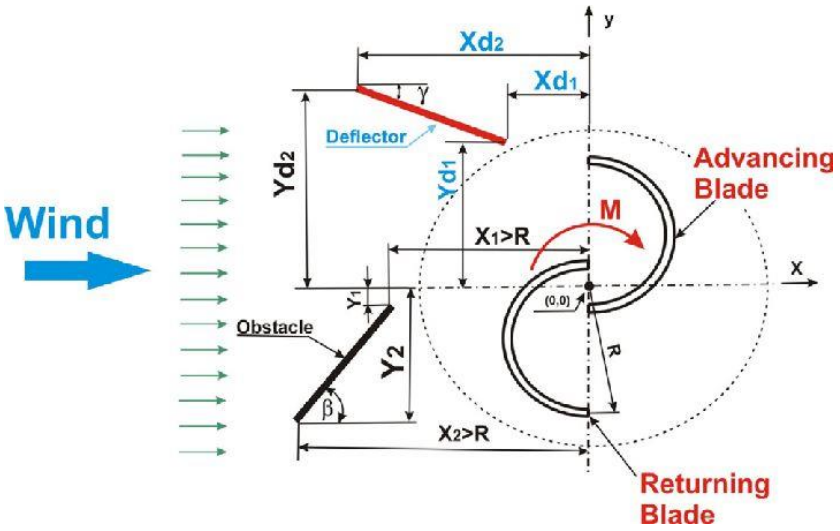


Fig: Working with wind flow.

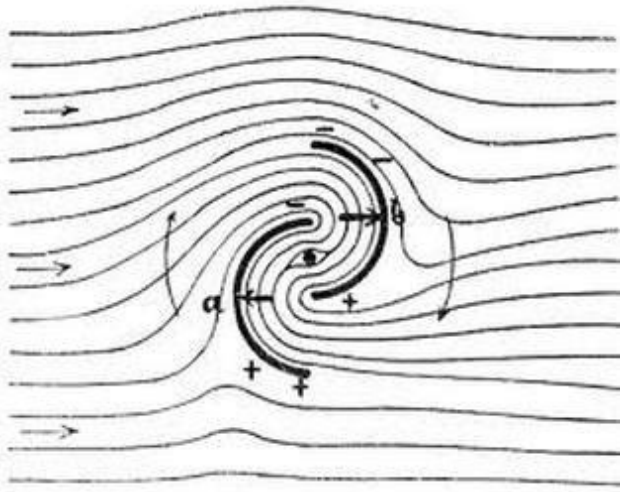


Fig: Wind flow direction.

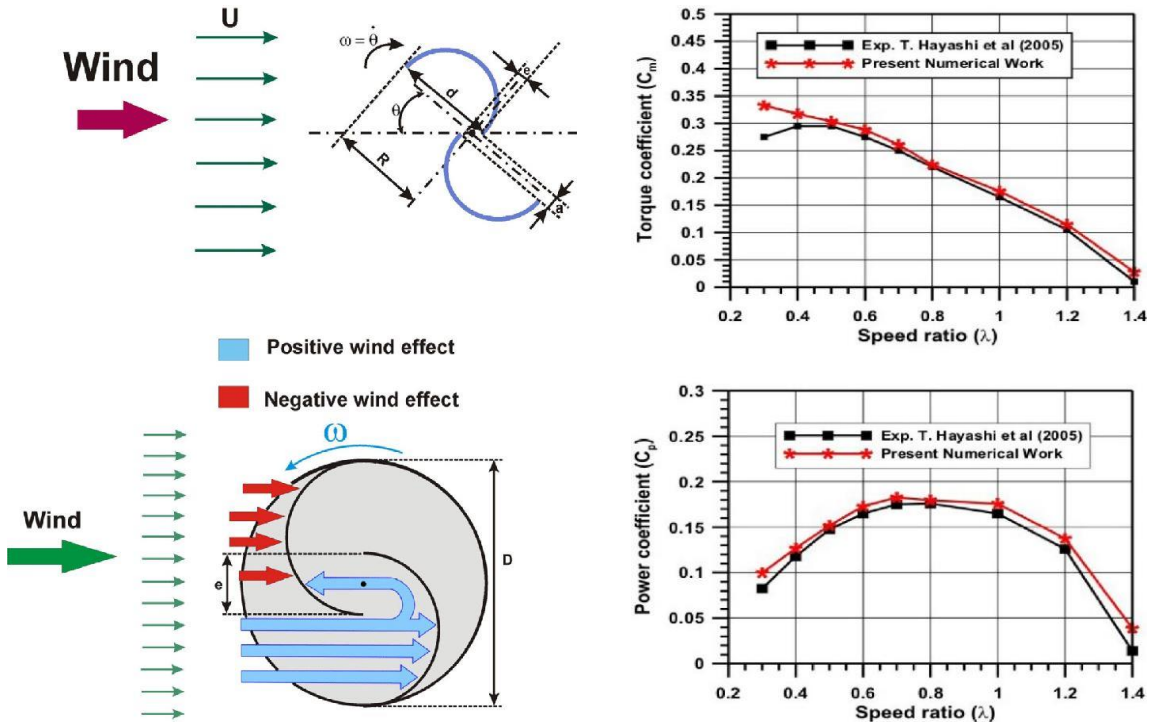


Fig: Positive & Negative wind effect with graphs.

4.3 Result Analysis:

Table: Performance chart (A)

When blade in the maximum distance			
Wind speed (Km/hr)	RPM	Voltage (V)	Distance (mm)
4	276	1.11	0
5	340	1.82	0
7	500	2.70	0
8	550	3.10	0
9	605	3.75	0

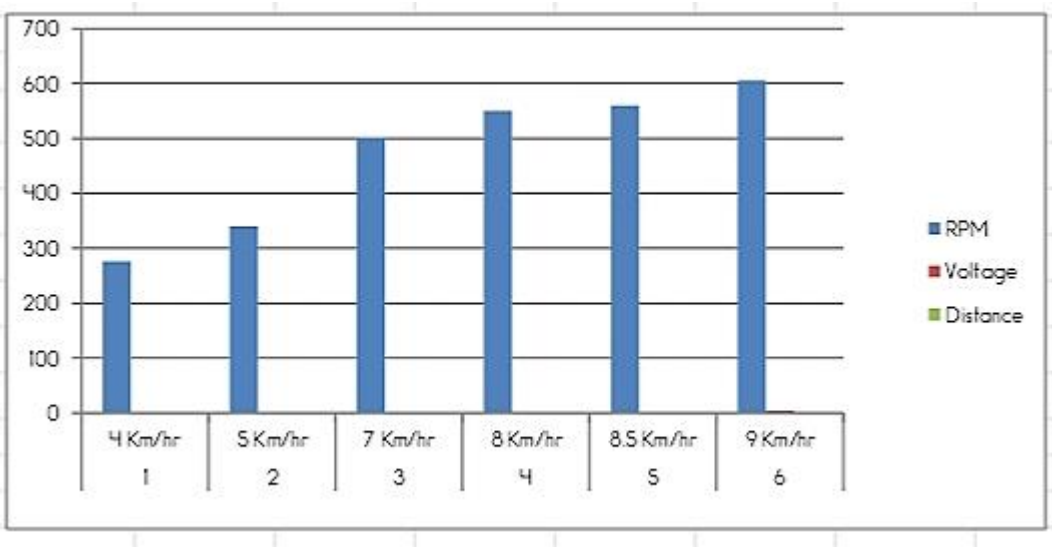


Figure : Increasing output according to wind speed.

Table: Performance chart (B)

When blade in the medium distance			
Wind speed (Km/hr)	RPM	Voltage (V)	Distance (mm)
4	210	0.89	30
5	280	1.12	30
7	335	1.80	30
8	360	2.00	30
9 Km/hr	388	2.30 volts	30 mm

Table: Performance chart (C)

When blade in the minimum distance			
Wind speed (Km/hr)	RPM	Voltage (V)	Distance (mm)
4	130	0.50	60
5	170	0.73	60
7	200	0.82	60
8	220	0.95	60
9	238	1.05	60

4.4 Conclusion:

We’ve started with the introduction in the first chapter where we have tried to illuminate the future age of tne wind power and what to be and how to approach our objectives. In the second chapter we’ve tried to explain the actual theory and diagrams for the project. Then in the third chapter we’ve explained the design and construction with equipment list, project images, description of equipments and the sensors and their working principles. At the next we discussed about the result and its advantages and limitations. Then we’ve estimated its cost and finally provided the programme to operate/run the system.

It is concluded from this research that with appropriate investment in renewables, the world can achieve 100% clean energy production by 2050. With the cost of wind turbines has fallen by nearly 1/3rd since 2009, it is believed that the wind has the potential to provide 20% of global electricity production in 2030, creating 2.4 million new jobs and reducing CO2 emissions by more than 3.3 billion tones per year. Worldwide wind capacity reached 837GW in 2022. If the right investment and the anticipated proper implementation of a renewable energy system, renewable energy and energy efficiency can provide over 90% of the reduction in energy-related CO2 emissions. Offshore tulip type wind turbines are the vision of our future technology and the floating wind turbine will have major implications.

Chapter Five

Conclusion & Recommandations

5.1 Introduction:

Assessment of Research Needs for Wind Turbine Rotor Materials Technology.
Simple cross-sectional analyses and computer codes need to be developed for determination of sectional elastic constants in composite blades with elastic couplings. These design tools should consider blade parameters such as curvature, twist, taper, and, above all, completely general material/geometry.

An aeroelastic design code should be developed for wind turbine blades. This would permit the investigation of aeroelastic tailoring as a passive control mechanism.

An investigation of new active control techniques for wind turbine blades should be initiated. This should be aimed at a new generation design in which gust loads are essentially reduced, thereby minimizing over-design of blades.

5.2 Limitations:

Although our project has many applications and benefits but there are some limitations of the project as well and the good thing is that these limitations are minor and doesn't affect the efficiency of the system.

- It's a demo project, that's why its area is very limited.

- Project may response slow for instrument quality. Real-life project will be work perfectly.

- Many types of development are possible in this project also use alternatives equipment's.

5.3 Future scops:

- To improve the blade manufacturing process so that quality variations and cost are minimized.
- To lower the operating stress levels by altering the structural/configuration design.
- To reduce the cost of blades enough so that periodic replacement becomes cost-effective.
- To improve the material properties and design capability so that the structure will withstand higher stresses, or the same level of stress for a much longer period of time.

5.4 Conclusion:

At the end of the project we can say the project has a large potential to do much development with it as the previlages described in below is obtained by the project:

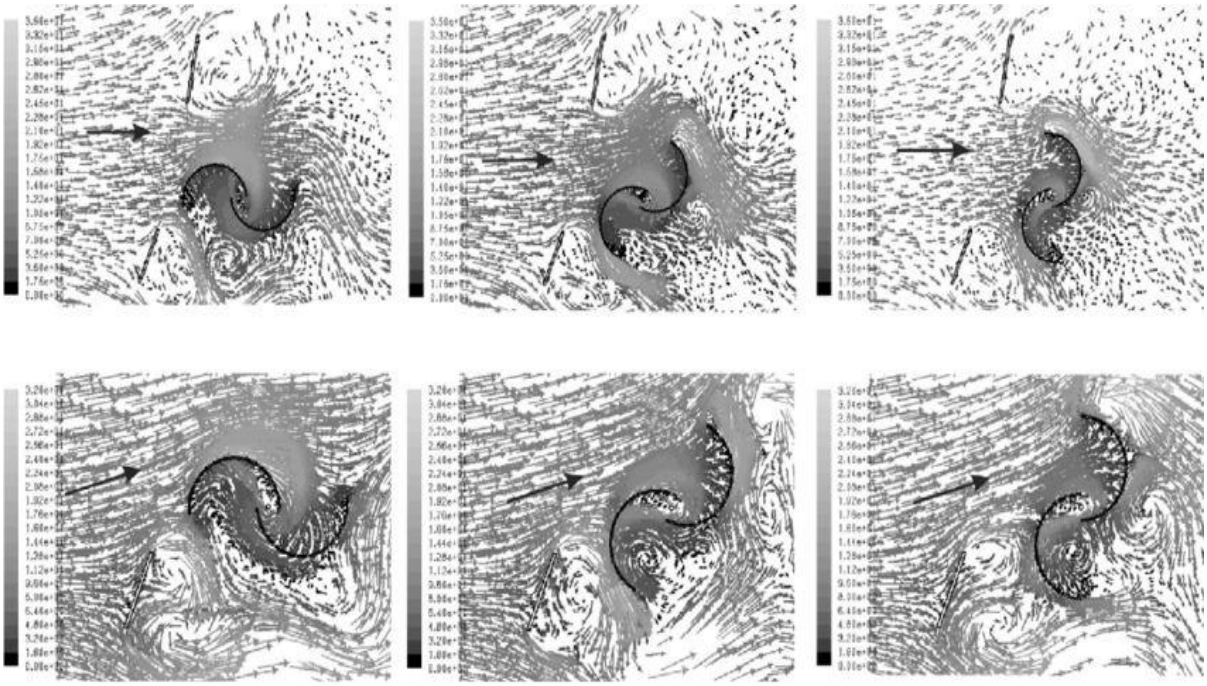


Fig: Wind flow direction.

- The advantages of a vertical axis wind turbine include the following.
- Safety for manpower.
- Scalability.
- It can generate electricity in any direction of the wind.
- It doesn’t require a strong supporting tower because the gearbox, generator & othercomponents are arranged on the base frame.
- As compared to horizontal axis turbines, these are cheaper to design.
- Installation is easy as compared to other types.
- These are portable so we can simply move from one location to another.
- These are designed with fewer speed blades.

- It works in all weather conditions like variable winds & mountain conditions.
- These are allowable where taller structures are not allowed.
- Its operation is simple so it doesn’t bother people in residential areas.
- To operate these turbines, we don’t require any large mechanisms.
- These are economical, quiet, efficient & ideal for residential energy sources, particularly in urban areas.

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