Faculty of Electrical Technology and Engineering

VERTICAL-AXIS WIND TURBINE FOR BLOWER APPLICATION BY USING OLD MOTOR TO GENERATE ENERGY

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Bachelor of Electrical Engineering Technology with Honours

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A project report submitted
in partial fulfillment of the requirements for the degree of
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I declare that this project report entitled "Vertical-Axis Wind Turbine For Blower Application By Using Old Motor To Generate Energy" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electrical Engineering Technology with Honours.

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DEDICATION

I would like to dedicate this project to the people whose unceasing support and encouragement guided me through this difficult but rewarding journey.

To my family: thank you for your unending support, understanding, and love. Your confidence in my skills has always given me courage, and I appreciate all the sacrifices you've done to support my career.

To my supervisor (Dr. Zul Hasrizal Bin Bohari), thank you for your guidance, wisdom, and the knowledge you've imparted. Your passion for the subject matter has inspired me to push the boundaries of my understanding and to strive for excellence.

To my friends who provided a much needed break from the intensity of this project and filled my life with laughter and joy. Your friendship made this academic adventure even more memorable.

I owe my intellectual growth to the countless hours spent in the company of textbooks, research papers, and code. This project is a testament to the collective effort of those who have contributed to my education and personal development.

Finally, I dedicate this work to myself, including the restless nights, the times when I doubted myself, and the unwavering quest for knowledge. I hope that my endeavour serves as a testament to tenacity, willpower, and pursuing one's passion.

ABSTRACT

In some regions with an abundance of wind resources, wind power generation is commonly used to generate electrical power. Vertical-axis wind turbines can be used to generate electricity. The increase in the VAWT price and the unpredictability in wind speed that can get variable power production. Besides that, there was also a literature review on the performance of wind turbine when implemented at blower application since the wind generated from blower was very strong. Hence, it is necessary to study the operation of VAWT systems and investigate the effect of wind speeds on wind turbine performance, measure the output of wind turbine at the blower application by using different type of material, sizing, weight, and shape of the wind blades., and test and develop how the old motor can be converted into the generator for the VAWT to generate electricity. The VAWT has successfully been built with different types of material for the wind blade. The anemometer, digital multimeter, clamp meter was being used to measure the performance for this project and was being tested in high wind speed (m/s) rooms. The analysis result shows the old motor can still produce a small amount of energy when becoming the generator and the faster the wind speed (m/s) flow will contribute to the very high output VAWT will produce that make the project objective 1 and 3 being achieved. Thus, the aerodynamic design, low weight plus with strong material for wind blade provide high efficiency on wind turbines that make project objectives 2 been achieved.

ABSTRAK

Di sesetengah kawasan yang mempunyai sumber angin yang banyak, penjanaan kuasa angin biasanya digunakan untuk menjana kuasa elektrik. Turbin angin paksi menegak boleh digunakan untuk menjana elektrik. Kenaikan harga VAWT dan ketidakpastian kelajuan angin yang boleh mendapat pengeluaran kuasa berubah-ubah. Selain itu, terdapat juga tinjauan literatur mengenai prestasi turbin angin apabila dilaksanakan pada aplikasi blower memandangkan angin yang dijana daripada blower adalah sangat kuat. Oleh itu, adalah perlu untuk mengkaji operasi sistem VAWT dan menyiasat kesan kelajuan angin ke atas prestasi turbin angin, mengukur keluaran turbin angin pada aplikasi blower dengan menggunakan pelbagai jenis bahan, saiz, berat dan bentuk angin. bilah., dan menguji serta membangunkan bagaimana motor lama boleh ditukar menjadi penjana untuk VAWT menjana elektrik. VAWT telah berjaya dibina dengan pelbagai jenis bahan untuk bilah angin. Anemometer, multimeter digital, meter pengapit digunakan untuk mengukur prestasi projek ini dan sedang diuji di dalam bilik kelajuan angin tinggi (m/s). Hasil analisis menunjukkan motor lama masih boleh menghasilkan sedikit tenaga apabila menjadi penjana dan semakin laju aliran angin (m/s) akan menyumbang kepada keluaran yang sangat tinggi yang akan dihasilkan oleh VAWT yang menjadikan objektif projek 1 dan 3 menjadi. dicapai. Oleh itu, reka bentuk aerodinamik, berat rendah ditambah dengan bahan kuat untuk bilah angin memberikan kecekapan tinggi pada turbin angin yang menjadikan objektif projek 2 tercapai.

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δ	-	Voltage angle
p	-	Density of the wind, kg/m3.
π	-	Pie
C_p	-	The Wind energy utilization coefficient
v	-	voltage
m	-	mili

LIST OF ABBREVIATIONS

V	-	Voltage
VAWT	-	Vertical – Axis Wind Turbine
HAWT	-	Horizontal – Axis Wind Turbine
AC	-	Alternating Current
DC	-	Direct Curent
BDP	-	Bachelor Degree Project
PVC	-	Polyvinyl chloride
A	-	Area
m/s	-	Metre per second
CO2	-	Carbon dioxide

CHAPTER 1

INTRODUCTION

1.1 Background

Clean energy is defined as energy sources with little to no adverse effects on the environment or human health. These sources of energy are frequently renewable, which means that they replace themselves spontaneously and do not exhaust finite resources. A device called a vertical-axis wind turbine (VAWT) is used to transform kinetic energy from the spinning of the blade into electrical power. It is made from a rotor that is positioned on a tower and has blades that are intended to harness the energy of the wind and spin a shaft. The generator attached to this shaft transforms the rotational energy into electrical energy that may be utilized to run buildings and other buildings. VAWT are a clean and sustainable source of electricity. As nations look to lessen their reliance on fossil fuels and move towards a more sustainable energy future, they are gaining popularity on a global scale.

On the other hand, blowers are machines made to transport gas or air. They are often employed in many different applications, including industrial operations, air conditioning, ventilation, and more. Blowers are frequently used to regulate the flow and pressure of air because they generate airflow using fans or impellers.

1.2 Addressing Global Warming Through Weather Sensing Project

Figure 1.1 Goal 13 of UNSDG which is the climate change

Modern society now has a severe problem with pollution, which highlights the importance of finding and using clean, renewable energy sources. For instance, Bahrain burns 1.7 billion cubic feet of natural gas every day to create electricity, which results in the generation of 90.3 million kilograms of CO_2 daily [1].

One of the main topics covered by the Sustainable Development Goals (SDGs) of the United Nations is climate change. Taking swift action to mitigate climate change and its effects is a key component of Goal 13. Goal 13 aims to reduce the negative effects of climate change and create a more resilient and sustainable future for everybody by working together to cut greenhouse gas emissions and advance sustainable development.

1.3 Problem Statement

Due to the natural unpredictability in wind speed and direction, the main problem with wind turbines is their variable power production. The electric grid must be able to always balance supply and demand, therefore this fluctuation may make it difficult to integrate Vertical-axis wind turbine (VAWT). Additionally, VAWT may have an adverse effect on the surrounding area's aesthetics and noise levels, which may cause some residents to object. Due to their frequent distant locations and need for specialized maintenance equipment, VAWT maintenance and repair expenses can also be a significant problem. Besides that, the most difficult part of operating a wind energy system is assuring its dependability and uncompromising power curve while minimizing total operating costs and quality. Finally, although the price of wind energy has considerably fallen in recent years due to advancements in technology, the initial cost of building a VAWT can be high.

1.4 Project Objective

The project's primary goal is to reduce the usage of fossil fuels that had critical effects to climate change which have led to the emission of destructive greenhouse gases into the atmopshere.

Specifically, the objectives are as follows:

a) To study the operation of VAWT systems and investigate the effect of the wind speeds on wind turbine performance.

b) To test and develop the wind turbines by using the old motor to generate electricity.

c) To measure the output of wind turbine performance at the blower application by using different type of material, sizing,weight and shape of the wind blades.

1.5 Scope of Project

The scope of this project are as follows:

a) This project mainly focus on high speed location that need to conduct in lab environment.

b) This project will serve the prototype to illustrate the concept and ideas of VAWT

c) This project design to small amount AC and DC power to be stored.

d) MATLAB simulation will be used to conduct the project software.

e) The blower fan with the maximum speed of 20 (m/s) have been used for the wind speed.

f) Anemometer is used to measured the wind speed from the blower fan.

g) Digital multimeter and clamp meter is used to measured the AC and DC voltage and DC current.

1.6 Summary of this Chapter

Chapter 1 is about the introduction to this project such as the background project which tells the VAWT operation and applications, the problem statement of the VAWT which led into why this project does was created to reach the objective. Besides that, it also tells the scope of the project which means the limit or boundaries this project can be achieve which is very useful to clear a high expectation.

Chapter 2, it will cover the past project research that related to this VAWT which is very important that helped me to become familiar with numerous research methodologies and the most important one is to get to know the limitations of the previous project that allows me to refine my own research design and method.

Chapter 3 is the method of how to develop this project which involves the development of flowchart, Gant Chart and milestone and all components project that required and project construction.

Chapter 4 is the data and analysis which involves the software and hardware data analysis result. This chapter is very important because it gives an approach to measure the project's effectiveness or success. Therefore, the data needs to be based on the project objectives to ensure it achieved its intended outcomes.

Chapter 5 is the conclusion of all the chapters and the achievement during the BDP for sem 1 2023/2024 tells the improvement of this project especially in future work.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The literature review is the past study from the researcher which mostly can be found from the articles, journals, and reports which related to project and challenge which involves the scope and design of the project. Besides that, it is also one of the important components of every research since it supports understanding current knowledge, identifying research gaps, and building a strong basis for individual studies.

2.2 Type of Wind Turbine

i) Vertical-axis Wind Turbine

Figure 2.1 Show the vertical-axis wind turbine (VAWT) [2]

The primary rotor shaft of a vertical axis wind turbine (VAWT) is positioned vertically and perpendicular to the ground. VAWTs feature rotor blades that spin on a vertical axis, in contrast to horizontal axis wind turbines (HAWTs), which have their rotor blades situated on a horizontal axis. When compared to HAWTs, Wind Turbine with Vertical Axis (VAWT) may generate more wind energy than Wind Turbine with Horizontal Axis (HAWT). This method enables the turbine to run in any weather, including hurricanes and storms. Both a clockwise and an anticlockwise rotating axis are present in these blades [2].

ii) Horizontal axis wind turbine (HAWT)

Figure 2.2 Horizontal-axis wind turbine [3]

The primary rotor shaft and generator of a horizontal-axis wind turbine (HAWT) are placed horizontally and parallel to the ground. It is the most typical design for substantial wind turbines that produce energy. Due to the turbine blades' natural movement in relation to the wind direction, their efficiency is great. HAWTs are heavy and installing them is difficult [3].

2.3 Formula Related to VAWT Project

i) Kinetic energy of a given mass of air formula for VAWT

$$P = \frac{1}{2}\, m v_{\infty}^{2}$$

P = wind power per minute. Equation (2.1)

m = fluid mass per time.

V_{∞}^{2} = the average wind speed upstream from the wind turbine

The wind turbine serves as the vital generator of driving torque. It has the capacity to change over the mechanical vitality utilized to drive the generator into motor vitality. The wind creates an axisymmetric stream tube as it moves through the wind turbine, according to the ideal stream tube theory. A wind turbine's capacity for capturing wind energy is influenced by the tube's inner discussion's active energy [4].

ii) Formula for fluid mass per unit of time.

$$m = pAV_{\infty}$$

p = Wind density in kg/m3.

A = the wind wheel's sweep area inside the flow tube, measured Equation(2.2) in m2.

V_{∞} = the average wind speed upstream from the wind turbine.

Using this mass flow rate and the wind speed, one may determine how much kinetic energy is there in the wind. The quantity of captured kinetic energy, which is proportional to the square of wind speed, influences the power output of the wind turbine. As a result, accurately predicting the mass flow rate is helpful in estimating the efficiency and power output of a wind turbine.

iii) The formula for wind energy per area.

$$P = \frac{1}{2} C_p \ pAv_{\infty}^{3}$$

$C_{p=}$ The Wind energy utilization coefficient

A = the wind wheel's sweep area inside the flow tube, measured in m2. Equation(2.3)

V_{∞}^{3} = the average wind speed upstream from the wind turbine.

This equation is one of the important factors for the engineers to design wind turbine systems. This equation can be used for both horizontal and vertical-axis wind turbines except for the rotor swept area (A). For the VAWT, the swept area can be calculated by:

A = π d h

d = the rotor's diameter (meters)

h = the rotor's height (meters) Equation(2.4)

From this calculation formula, it is clearly seen that the higher the value of the diameter and the height of the rotor, the higher the swept area will be as a bigger volume of air is intercepted by a wind turbine, which increases the amount of kinetic energy it absorbs.

2.4 The Advantages and Disadvantages of Each Journal Related to This Project

Table 2.1:Show the advantages and disadvantages of each journals

No.	Title	Year	Authors	Advantages	Disadvantages
[1]	Design and Implementation of a Smart Vertical-Axis Wind Turbine.	2020	Moath Waleed , Mohammad Abdul Rasheed , Anis Ur Rehman, Omar Bahri, Ahmed Mohamed, Zouhir Bahri1, and Omar Al-Abbasi.	Able to remotely the operation through smartphone.	Circuit and coding is quite complex.
[2]	Performance of a Small Horizontal Axis Wind Turbine with Blade Pitching.	2020	El-Okda Y, Emeara M	Able to know the effect of wind turbine blade toward its performance.	There is no the picture of wind blades shown in the journal.
[3]	Analysis on the Effectiveness of Vertical Axis Wind Turbine for Domestic Consumers.	2020	M. Sateesh Kumar* , Y. V. Pavan Kumar* , D. John Pradeep* , Ch. Pradeep Reddy.	Present and compare all the type of wind turbine in term of their performance.	Simulation for all the wind turbine type quite complex.

No.	Title	Year	Authors	Advantages	Disadvantages
[4]	Vertical-Axis Wind Power Generation System Based on Wind Energy Characteristics of Highway Vehicle Bypass Flow.	2023	Q. Yang, F. Yan, S. Zhang, S. Li, C. Yin, and Y. Wang.	Can monitor the wind speed with different distance.	Required big space to be install and high initial cost.
[5]	Study of Vertical Axis Wind Turbines with Solar PV for Energy Storage in Battery Swapping Stations or for Electric Vehicles on Highways Using HOMER Pro.	2023	L. Solanki, S. Vadhera, and K. S. Sandhu.	Two combination system (if 1 fails , other system can be backup so that continuous power can deliver to the load.	Lower space efficient and high initial cost.
[6]	Smart Recharge of Electric Vehicles Using Wind Energy	2021	S. M. Samuel, S. P. Sam Isaac, and M. Rajasekaran.	Q-blade design which can give the maximum efficiency to produce higher output.	High initial construction cost.
[7]	Power Scavenging Using a Darrieus Type Vertical Axis Wind Turbine on Highways.	2023	R. Kothai, T. Porselvi, A. Sri Ari Priya, V. Sandhiya, and R. Ajithasri.	The output power can be used for lighting or supply to grid to sell it.	System circuit quite complex.

No.	Title	Year	Authors	Advantages	Disadvantages
[8]	Smart Highway Technique using Wind Turbine with Vertical Axis (VAWT).	2023	T. A. Srinivas, M. J. S. Mohamed, S. A, P. Sukania, A. Pathani, and K. Sekar.	Lower construction and transportation cost.	Less efficiency, less wind speed due to shorter structure
[9]	Polycarbonate Bladed Highway Wind Turbine: A Case Study.	2021	Qusai S, Esraa S, Aseel R.	Using light material such as polycarbonate for the blade so that the wind can rotate even faster.	The cost of polycarbonate is more expensive than PVC.
[10]	IoT Based Hybrid Green Energy Driven Highway Lighting System.	2019	Md. Arafatur Rahman, Marufa Y. Mukta, Abu Yousuf, A. Taufiq Asyhari, Md. Zakirul Alam Bhuiyan, Che Yahaya Yaakub.	Consist hybrid system which the battery can be charge/discharged to feed toward lighting.	Required solar pv to support the battery system.
[11]	Harnessing of Electrical Energy Through Vehicular Air Drag on Highways For Lighting Load Applications.	2019	J.M.Cuya, J.L.Luzano, E.E.Chua, F.V.Cudia and M.C.Pacis.	Contain the aerofoil shape blade which provide benefit through turbulence.	The blade of the wind turbine is heavy that will effect the output power.
[12]	Hybrid J-Type Darrieus and Savonius Vertical Axis Wind Turbine Capable of Harvesting Roadside Wind Energy.	2022	James Angelo C. Lipiao, Nicca Mae M. Divina, Ronald Vincent M. Santiago, Carlos C. Hortinela IV.	Contain IOT system which the output power can be monitoring through "cloud".	Initial cost construction and maintenance is very expensive.

No.	Title	Year	Authors	Advantages	Disadvantages
[13]	Implementation of Hybrid Photovoltaic and Wind Energy Conversion System for Traffic Surveillance and Road Lighting.	2019	Kejie B. Enciso, Manuel Jose III, Rajyl Loria, Jude Carlo Terrado, R.V.M. Santiago and Michael C. Pacis.	Can monitor both solar dan wind turbine output.	Initial cost construction and maintenance is very expensive.
[14]	Design of Harmony Vertical Axis Wind Turbine for Power Generation.	2021	S. Rajendran, M. Vallarasu, P. M. Kumar, K. Rajesh, T. H. Prasath, and S. Revathi.	Contain additonal security system for car thief cases.	Circuit is complex and high initial construction cost required.
[15]	A Novel Vertical Axis Wind Turbine for Energy Harvesting on the Highways.	2019	Ashar Iqbal, Venkatratnam Chitturi, K V L Narayana.	Simple construction and low maintenance.	Volt-Amps Reactive (VAR) leading for excitation.
[16]	A Hybrid Power Generation System Utilizing Solar and Wind Energy on Highways.	2022	U. Mittal, S. Verma, A. Kumar, S. Singh, G. Varshney, and A. Pawar.	A Hybrid system where it can also generated power through solar.	Contain gearbox that very expensive in the market.

No.	Title	Year	Authors	Advantages	Disadvantages
[17]	A Hybrid Model of Vertical Axis Wind Turbine-Solar Power Generation for Highway and Domestic Application.	2018	A. Bavchakar, P. K. N. Chougale, S. S. Belanekar, S. P. Rane, and N. B. Sawant.	A Hybrid system where it can also generated power through solar.	Initial construction cost is very expensive.
[18]	Respirator with Air Blower and Air Quality Detector.	2022	Rahman M, Elsheikh E	Lower construction and transportation cost.	System circuit quite complex.
[19]	Numerical study of energy recovery from the wakes of moving vehicles on 1 highways by using a vertical axis wind turbine.	2017	W. Tian, Z. Mao, X. An, B. Zhang, and H. Wen.	Rotor will produce highest power coefficient from heavy vechicles like bus.	Rotor is unable to produce power from moving cars in the fast lane.
[20]	The Case of Highway Vertical-Axis Wind Turbines in the United States.	2020	L. C. Kunkel and D. M. Hall.	High traffic locations will get the most productivity from the turbines.	Construction/maintenance site very dangerous toward the workers.
[21]	Design of Small Scale Vertical Axis Wind Turbine.	2023	Chandrashekhar P K, Sachin Managuli , Shashank A.	Lower construction cost.	System circuit quite complex.

No.	Title	Year	Authors	Advantages	Disadvantages
[22]	Experiment Validation of Vertical Axis Wind Turbine Control System based on Wind Energy Utilization Coefficient Characteristics.	2015	Chongyang Zhao1,2' Jun Luo1 'Shaorong Xie1 ,Hengyu Li	Explain how does the block diagram of wind turbine.	Higher construction cost.
[23]	Experiment with a Prototype of Vertical-axis Small Wind Turbine with a Wind Lens.	2023	Keita Shimizu, Hiroyuki Abo, Masaki Sato.	Learn the shape about savional design.	Simulation software very complex.
[24]	Flow Physics Analysis of a Vertical Axis Wind Turbine Using FloEFD.	2021	Genc M, Sekhoune Ozden K	Learn about the air flow of wind speed.	Simulation software very complex.
[25]	Improvement of Generating Efficiency of Vertical-axis Wind Turbine with Wind Lens.	2022	Shimizu K, Yoshinari T	Learn to improve the performance of wind turbine.	Circuit is complex and high initial construction cost required to do testing.

No.	Title	Year	Authors	Advantages	Disadvantages
[26]	Modeling and Comparative Performance Analysis of Different Bladed Vertical Axis Wind Turbine (VAWT).	2018	Khoharo H, Kumar L, Sharif Jamali M	Learn about the "C" shape design wind blade.	Material of wind blade very expensive.
[27]	Optimization of Vertical Wind Turbine Performance in Tunnel Area of Coal Conveyor.	2021	Fauzih R, Arifin F, Kusumanto R	Learn about the new design of wind blade which is Savonius and Darrieus Combination Turbine.	Higher cost construction.
[28]	Research on Aerodynamic Performance of J-type Blade Vertical Axis Wind Turbine.	2020	Anhui da xue, Dongbei da xue	Learn about aeodynamic design blade contributed higher energy to be harvest.	Simulation design to complex.
[29]	Wind Turbine Model Testing using All Side Fans Arrangement to Create Turbulence.	2017	Datta. S. Chavan, Jasmine Cheema, Jaywant Sankpal, Indu, Tanya, Anupama Singh , Anamika, Rahul Yadav.	Learn about the turbulence created by fan can effect the performance of wind turbine.	Higher cost construction.

No.	Title	Year	Authors	Advantages	Disadvantages
[30]	Wind Turbine Model Testing using Blower Fan Sliding Mechanism to Create Wind Shear.	2017	Datta. S. Chavan, Sapana, Jaywant Sankpal, Indu, Anupama Singh, Ravleen Kaur Manocha, Anamika Shukla, Niranjana.	Learn about the performance of wind turbine toward blower.	High cost construction.
[31]	Vertical Axis Wind Turbine Blade Manufacturing Using Composite Materials.	2021	Bucur I, Malael I, Predescu M.	Learn about the effect of weight on wind turbine blade.	High cost construction.
[32]	DEFLECTABLE BLADES VERTICAL AXIS WIND TURBINE.	2018	G.L. Crisostomo, J.D.Cordero, J.A.Echare, RM Layes, P.O. Monana, S.V. Perez, E.R. Resuma, D. Saldua, L.M. Tayopan.	Learn about the new shape of wind blade.	Contain gearbox that very expensive in the market.
[33]	Aerodynamic Performance and Wake Effect of New type Nautilus Blade Vertical – Axis Wind Turbine.	2020	Mengchai Gao , Zheng Li, Liyuan Cheng , Wengda Zhang.	Learn about the new shape of wind blade.	High cost construction.

2.5 Summarize of The Comparison and Different Between All the Journals

From the table 2.1, it clearly stated that the big difference between all the project in the journals is the combination of the hybrid system.The hybrid system is the combination of the solar pv and wind turbine system.The advantages of this sytem is the solar PV can act as a backup supply when the wind turbine cannot operate at the minimum output probably due to the minimum number of vehicles that passed by or wheather condition.Although this system provide a stable and continous supply, the cost construction to build this project is very expensive due to the main components like generator and solar panel which is one of the cores items to build this system.Meanwhile, the other journals is just the only wind turbine system while the difference of this system is just the material of the wind blade for example made from PVC pipe or polycarbonate.

2.6 Summary of this Chapter

This chapter mostly describes a prior project carried out by various researchers, all whose system-building goals were diverse in application but the same in terms of background. This chapter is very important because it helped me to become familiar with numerous research methodologies and the most important one is to get to know the limitations of the previous project that allows me to refine my own research design and method. For the next chapter, it is going to explain a lot about the details of my project such as the circuit simulation, component that required, flowchart, the initial experiment setup and the Gantt chart or project schedule.

CHAPTER 3

METHODOLOGY

3.1 Introduction

In general, this chapter will explain about the procedures and methodologies needed to develop this project which involves the hardware components only which is by using the old motor to generate electrical energy. This project will make use of a synchronous motor which can be renovated or converted into the generator that will be used as a main core of the vertical-axis wind turbine (VAWT) system and will be tested on the laboratory environment.

3.2 Methodology

To conduct research, address issues, or accomplish certain goals, a methodological approach or set of methods is employed in a particular field of study or practice. It provides a road map for gathering and analyzing data, making choices, and coming to conclusions by outlining the overarching structure and rules for carrying out a project, research, or inquiry. This is a small prototype that will analyze the efficiency of the VAWT at blower application to produce a certain amount of output power.

3.3 Sustainable Development of the Project

A wind turbine project's lifetime must be considered while developing it with a sustainable development focus. Here are some crucial things to remember:

1) Site Selection: Choose suitable locations for the installation of wind turbines based on wind resources, environmental impact assessments, and any societal repercussions. Steers clear of areas that are sensitive to the environment and takes care not to damage wildlife habitats.

2) Energy Efficiency: By increasing wind turbine efficiency and design, you may produce more electricity while cutting down on energy losses. This entails selecting the appropriate turbine size, blade design, and operational strategies to ensure optimal energy conversion.

3) Develop a decommissioning strategy to guarantee the secure removal and recycling of wind turbines at the end of their useful lives. To reduce waste and the negative effects on the environment, encourage component reuse and recycling.

4) Community Involvement: Involve community members and stakeholders in the project's planning and decision-making processes. Discuss problems, provide lucid information, and consider the benefits to the community, such as the creation of jobs, regional investment, and income-sharing schemes.

3.4 Project System Block Diagram

The most important factor that will affect the system is how much the wind speed needed to spin the shaft so that the generator can work on the principle of electromagnetic induction which change in magnetic field around a conductor to generate electric current in the circuit. Figure 3.1 shows the VAWT operation when using the electromagnetic concept to produce the AC electricity. Besides that, a rectifier circuit is used to convert AC – DC which is used to store the battery.

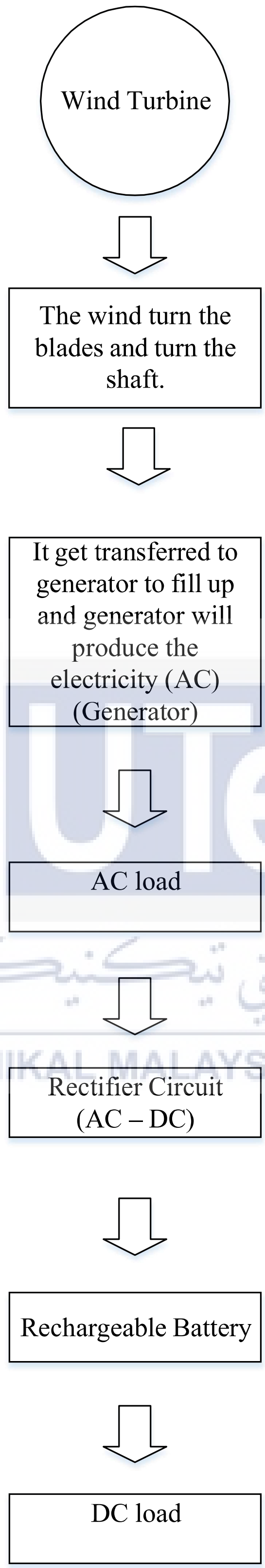


Figure 3.1 Block diagram of VAWT system

3.5 Project System Flowchart

A flowcharts offer a concise and organized summary of a process, enabling users to comprehend and evaluate the order of the events or choices involved. To represent various aspects, such as beginning and ending points, tasks or activities, decisions, inputs and outputs, and connectors or arrows to show the flow and direction, they employ standardized symbols and connectors. In this project, there will be 3 type of flowchart that include :

i) Main flowchart - The main flowchart gives a high-level overview of the operations and interactions of the system. It may not depict all the intricate interactions or stages that took place within the system, but it nevertheless provides a visual picture of the main tasks and direction of the system's functioning.

ii) Software flowchart - A software flowchart is a diagram that shows the structure and logical flow of an algorithm or software program. It displays the series of choices, activities, and stages made inside the software to complete a certain activity or objective.

iii) Hardware flowchart - A hardware flowchart is a diagram that shows the parts and connections inside a hardware system or device. It is also referred to as a hardware block diagram or hardware schematic diagram. It depicts the physical arrangement, construction, and connections of the hardware parts.

3.5.1 Main Flowchart Explanation

- Literature review

  In this part, the research on VAWT system is being studied to know the operation and materials of this project which is very important to increase the understand beforestart to implement the project.

- Initial Design

  The initial design will be used based on the laboratory or small room the stand fan to get the different wind speed.

- Construct and test software and hardware

  For this step, all the components will be bought and assembled for testing and data will becollected to complete the task, especially in data and analysis.

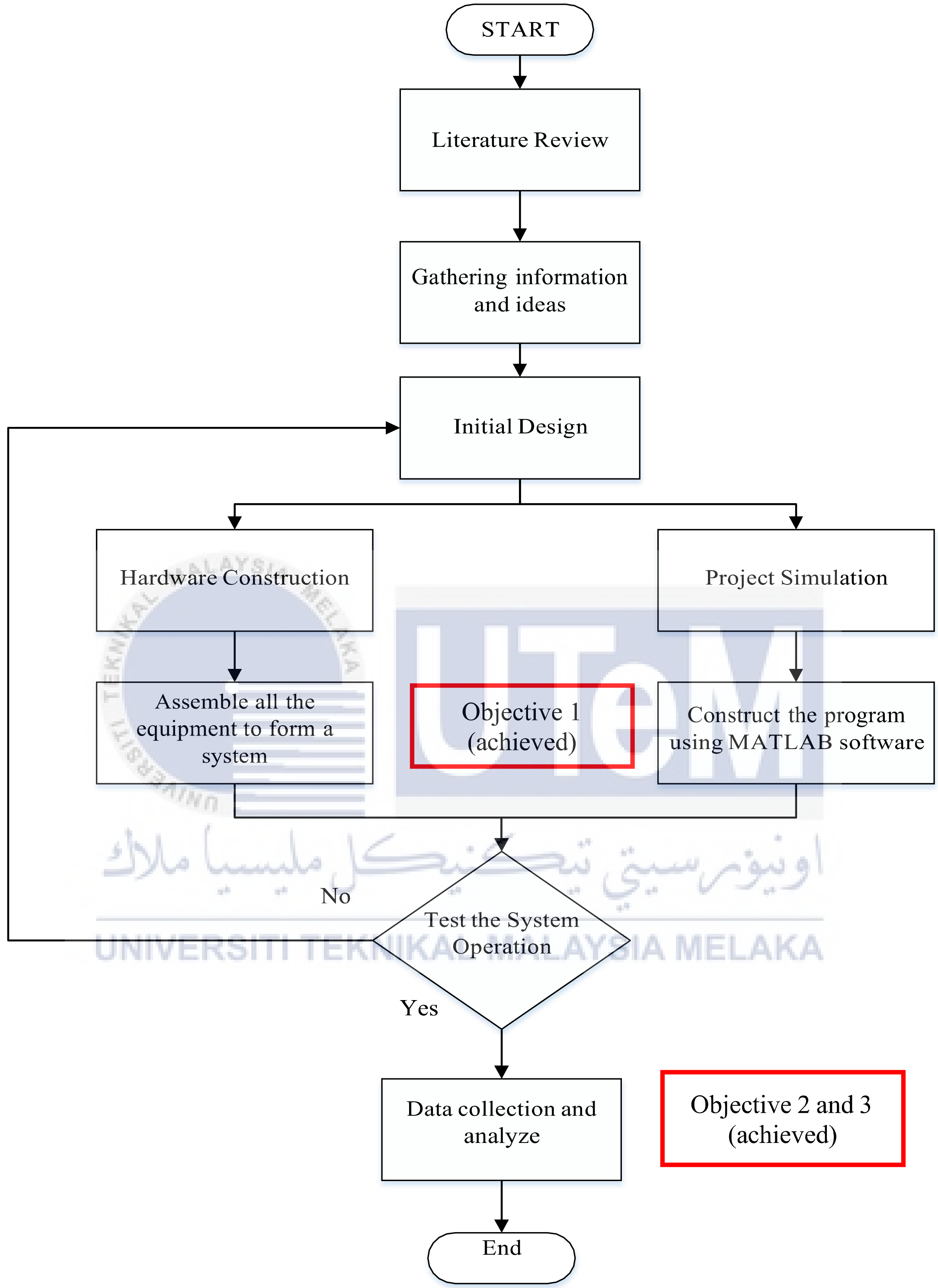


Figure 3.2 Main flowchart of this project.

3.5.2 Software Flowchart

Figure 3.3 belows show the flowchart software which is based on the MATLAB software.The generator speed and the pitch angle is being a constant variable as the wind speed (m/s) is constantly changed which is to determine the ouput which will be at the display and scope.

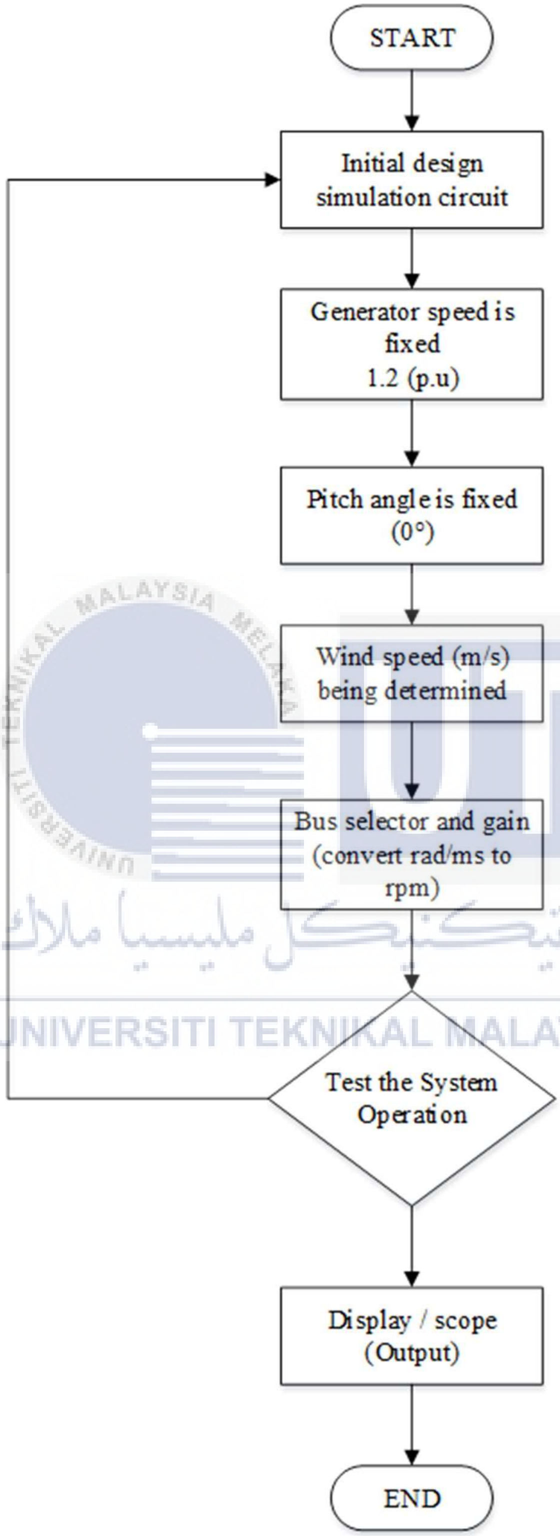


Figure 3.3 Software flowchart of this project.

3.5.3 Hardware Flowchart

Figure 3.4 shows the hardware flowchart of this VAWT system.The operation is almost the same as the normal wind turbine system except for the application which can be both contribute to AC and DC load where a rectifier will be installed in this VAWT system.

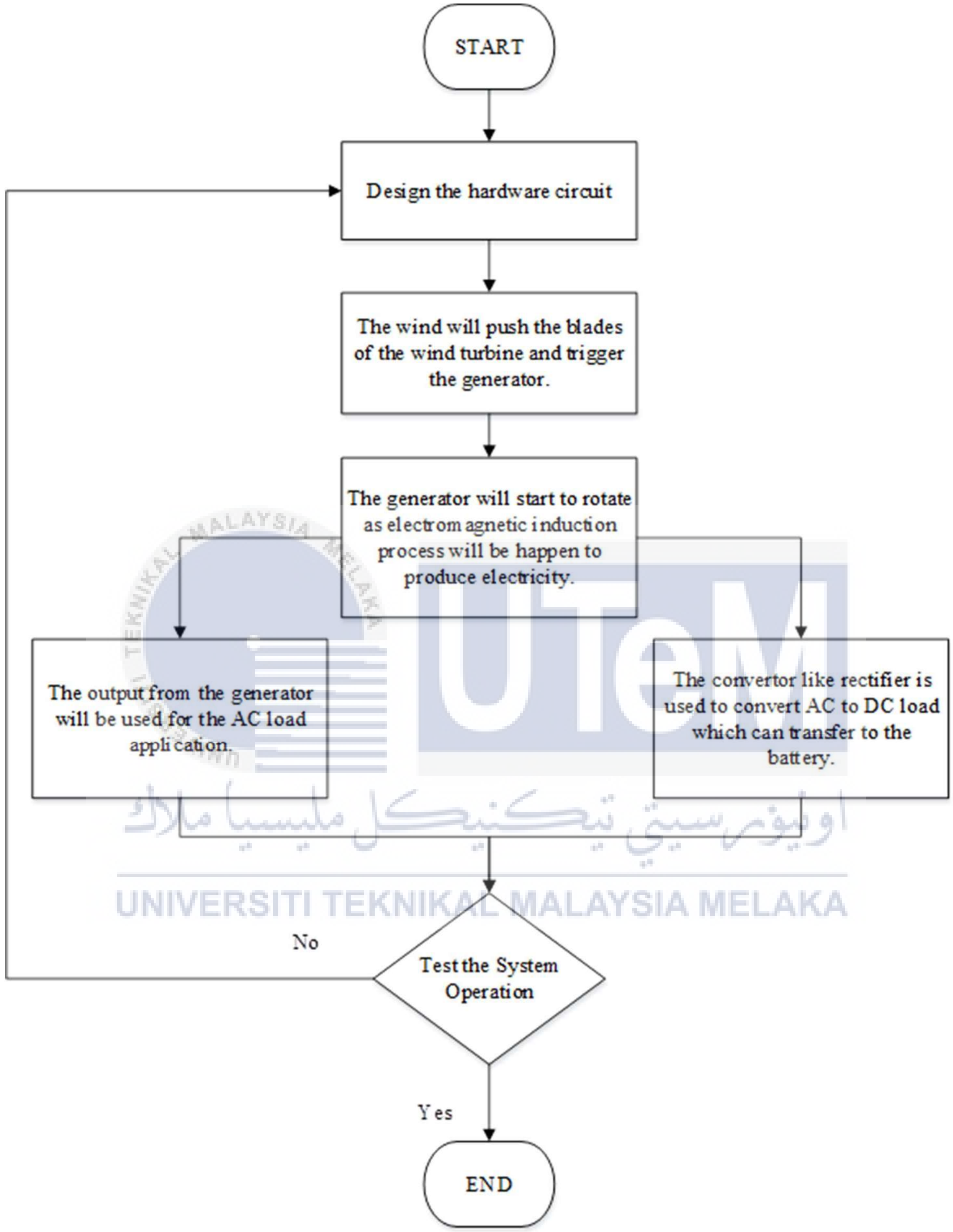


Figure 3.4 Hardware flowchart of this project

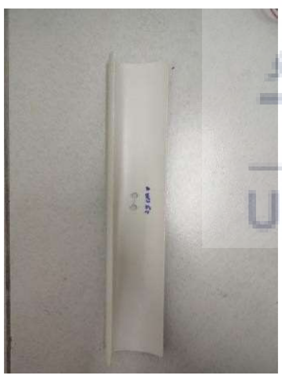
3.6 List of all Hardware Component

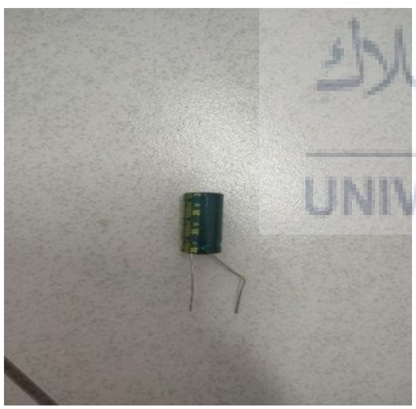
Projects need hardware components because they enable functionality, affect performance and efficiency, make integration and compatibility easier, allow for scalability and expansion, give dependability and durability, improve security, and provide support and maintenance. For a project to be successful and last a long time, selecting the appropriate hardware components is essential that can be seen at Table 3.1 below.

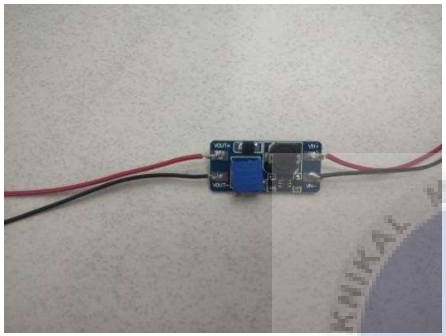
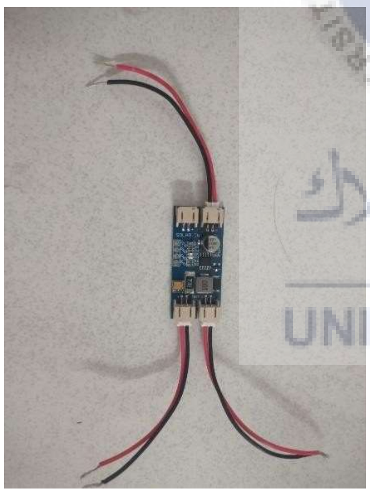
Table 3.1 List of the component required in this project.

Name of the components	Definition	Operation	Application
1) Permanent magnet synchronous motors 	• A type of synchronous electric motor that creates a magnetic field by attaching or embedding permanent magnets in the rotor.	• PMSM operates in synchronous mode, the rotor and the magnetic field created by the stator revolve at the same speed. High performance and efficiency are the outcome of this synchronisation.	• Used to convert the mechanical energy produce by the rotational blade of VAWT to generate electrical energy.

2) Anemometer 	• A device used to measure voltage, resistor and currents.	• The anemometer measures the number of revolutions or turns, from which wind speed is determined.	• Used to measure the wind speed (m/s) produce by the fan when implement in laboratory environment.
3) Digital Multimeter 	• A device used to measure voltage, resistor and currents.	• Ensure all the probe are connecting into a right port (negative and positive) and make sure to select the maximum range (scale) to prevent any damaged to the multimeter.	• Used to measure the voltage value produce by the wind turbine.

4) Bridge Rectifier 	• Used to convert alternating current (AC) to Direct current (DC).	• Uses one or more P-N junction diodes to convert alternating electricity to direct current. Diodes function as one-way valves that only let electricity flow in one direction.	• Used to convert alternating current (AC) generated by VAWT to direct Curent (DC) to supply it toward the battery.
5) Unplasticized Polyvinyl Chloride 	• plastic utilised for water pipes.		• Used as a blade of the VAWT system.

6) Waterproof Cement 	• Kind of cementitious substance designed to prevent water from penetrating and absorbing it.	• This involves increasing the cement's resistance to water penetration by combining it with certain additives or customized formulas.	• Used to make the base of VAWT system.
7) Capacitor (1000uF) 	• an electrical component used in a circuit that may store and release energy	• A potential difference is created when a voltage is applied across the capacitor because electrons gather on one plate while being repelled from the other by an equal number of electrons.	• Used to smooth and filter the output voltage in rectifier circuit.

8) Boost Converter (DC – DC) 	• A DC-DC (direct current to direct current) power converter circuit that raises the input voltage to a higher output voltage is called a step-up converter.	• An inductor stores energy from the input source during the "on" phase, while a diode releases this stored energy to the output during the "off" phase, increasing voltage.	• Used to boost the voltage from the rectifier to get the minimum input of solar charge controller.
9) Solar Charger Controller 	• an electrical component that controls and monitors the solar panel-based battery charging in photovoltaic (PV) systems		• Keep the batteries from being overcharged or deeply discharged to ensure maximum longevity and performance.

10) Soldering Iron 	• used to connect or bind metal components in electronics and metalworking by melting and then cooling a filler metal	• Through its heating element, which is usually a copper tip, electricity is applied. Solder is applied to the component junction once the heating element achieves a temperature high enough to melt it.	• Used to solder the boost converter that connected to solar charge controller.
11) L- shaped hook 	• Used to hang some item and clothes.		• Used to connect the wind shaft and the wind blade.

3.7 Hardware construction

i) Soldering process

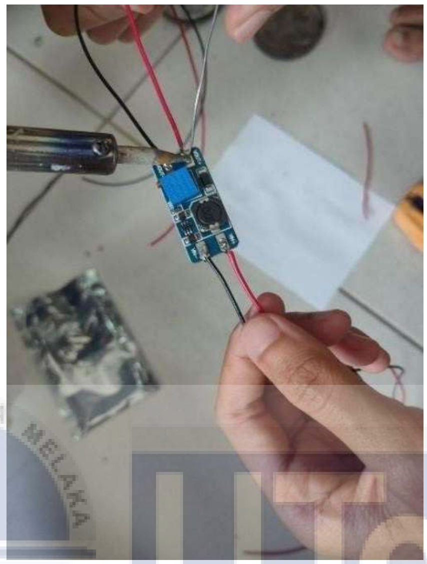


Figure 3.5 The process of soldering the electronic circuit

Soldering is a process used to join two or more metal components by melting and flowing a filler metal, known as solder, into the joint. Using a soldering iron or other heating tool, the surfaces of the metals that need to be connected are heated, which melts the solder and causes it to stick to the workpieces. Since solder usually melts at a lower temperature than the materials it is joining, there is less chance of component damage during the operation.Figure 3.5 show the boost converter that need to be solder so that it can be connected from the wind turbine to the solar charger controller.The process need to be carefully be done to avoid the component from being overheating.

ii) Project Base Construction

Figure 3.6 The base of VAWT using the cement material

Figure 3.6 show how does the base of VAWT was created by using the quick-dry cement.The process of making this base required very quick time because to avoid the cement from being dried completely before it can withstand the UPVC pipe.Besides that, the height of the UPVC need to be shorter to reduce the vibration produced by the wind blade

iii) Wind blade design

Figure 3.7 Type of material used for wind turbine blade

Figure 3.7 show how does the wind blade of VAWT was created by using 3 type of wind blade which is the PVC Class D, aluminium flat sheet and UPVC.The shape design for the material PVC Class D and aluminium flat sheet was design into "C" shapes while the UPVC was design into aerodynamic shape to make comparison about which design will get the better performance in term of harvesting the energy.

3.8 Project test development (No -load)

i) PVC CLASS D

Figure 3.8 Show the VAWT being tested using PVC Class D as wind blade

The equipment that is involved during this experiment is digital multimeter, clamp meter, anemometer and the blower fan.Therefore, data such as AC voltage, DC currrent and DC voltage had been collected as the wind speed (m/s) increase until it reach a constant value.Besides that, a rectifier circuit have been created to convert the AC voltage into DC voltage.The experiment is being tested in no-load condition because to make sure the generator from the VAWT is functioning properly when not under load.

ii) Aluminium flat sheet

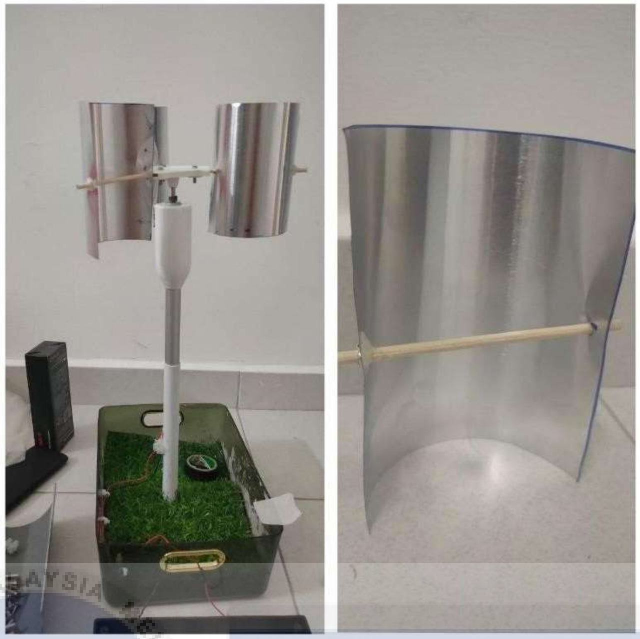


Figure 3.9 Show the VAWT being tested using aluminium flat sheet as wind blade

The equipment that is involved during this experiment is digital multimeter, clamp meter, anemometer and the blower fan.Therefore, data such as AC voltage, DC currrent and DC voltage had been collected as the wind speed (m/s) increase until it reach a constant value.Besides that, a rectifier circuit have been created to convert the AC voltage into DC voltage.The experiment is being tested in no-load condition because to make sure the generator from the VAWT is functioning properly when not under load.

iii) UPVC

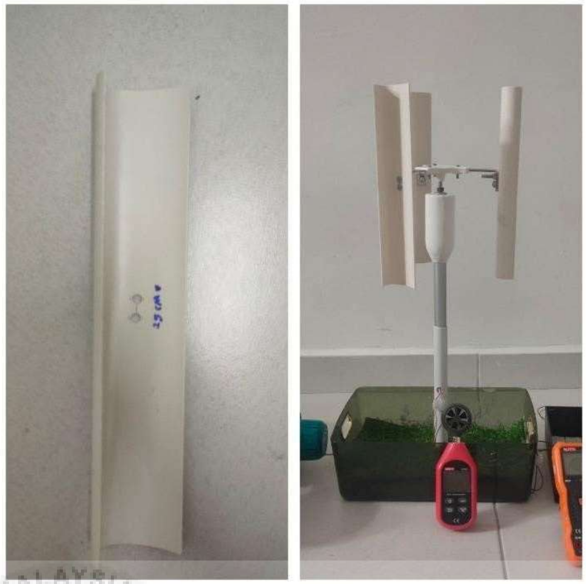


Figure 3.10 Show the VAWT being tested using UPVC as wind blade

The equipment that is involved during this experiment is digital multimeter, clamp meter, anemometer and the blower fan.Therefore, data such as AC voltage, DC currrent and DC voltage had been collected as the wind speed (m/s) increase until it reach a constant value.Besides that, a rectifier circuit have been created to convert the AC voltage into DC voltage.The experiment is being tested in no-load condition because to make sure the generator from the VAWT is functioning properly when not under load.

3.9 Project test development (load)

Material: UPVC

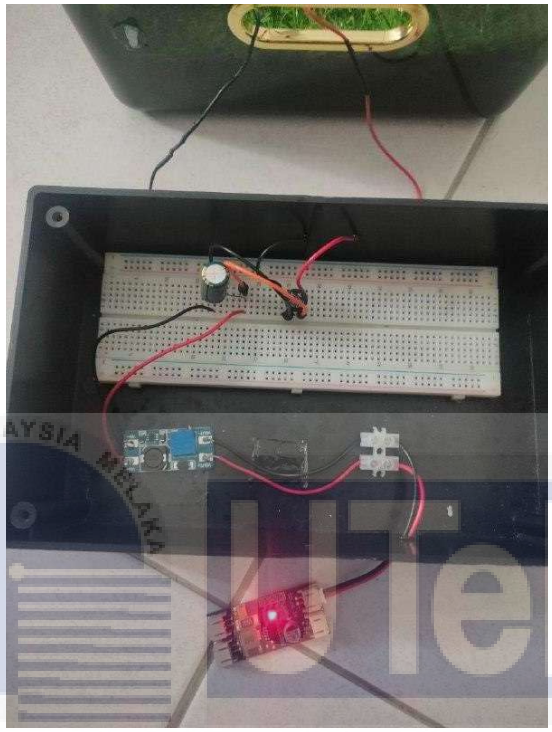


Figure 3.11 Show the VAWT being connected to the solar charger controller

Figure 3.11 show the rectifier had been connected to the load which is the solar charger controller.Solar charger controller is used as a indicator which is the led that when it light up tell the circuit is in process charging.At the connector, the voltage value had been measured to ensure how much the voltage drop when connected to the charger controller.Besides that, the PVC Class D and aluminium flat sheet is not suitable to be connected into solar charger controller since it input voltage provide very low.

3.10 Project hardware construction

Figure 3.12 shows how the hardware experiment had been conducted in the laboratory environment. The component requirement that is involved in the experiment is a digital multimeter, an anemometer, VAWT, rectifier, and a blower fan where the speed of the from is blower is constant while the material of the blade is variable and being tested. Besides that, AC and DC voltage has been measured to determine the performance of VAWT in terms of sizing, material, and weight.

Figure 3.12 Hardware analysis conducted in laboratory room

3.11 Project software construction

Figure 3.13 shows the simulation diagram of measuring the speed (rpm) for the VAWT constructed by the MATLAB software. The output of this circuit will be shown on a display and the scope with the speed (rad/s) that will convert to rpm.This circuit is running with constant genetor speed and the pitch angle.

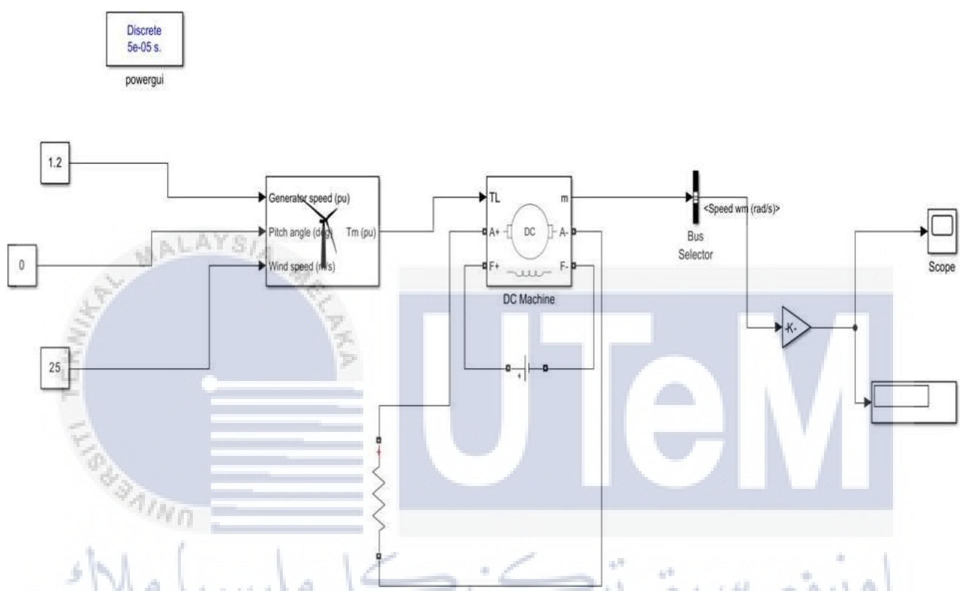


Figure 3.13 Simulation circuit of this project.

3.12 Gantt chart and key milestone

It is widely acknowledged that the Gantt chart is an essential and much appreciated project management tool, utilized to visualize a project’s schedule. When managing complex projects, Gantt Charts are an ideal tool for tracking timelines efficiently. They assist Project Managers by offering a visual summary outlining critical tasks' duration and deadlines enabling better oversight as well as effective allocation and prioritization of resources on various tasks ensuring timely completion within budget.

In BDP 1 and 2, there will be a total of 14 weeks to complete the BDP report and the project in each semester. In this semester (BDP 1), there will be mostly focuses on finding the project materials and literature review which will apply in chapter 4 which is the preliminary result that will archive one of the objective projects.

For BDP 2, the Gantt chart represents the future planning, which will mostly concentrate on the project's testing and construction. This project must be completed in 14 weeks before the final presentation, and it must fulfil all its targets.

A milestone in project management is an important occurrence or accomplishment that signifies a pivotal moment in the project's advancement. This vital checkpoint denotes a particular output, objective, or ruling moment that greatly contributes to the project's triumph.

Table 3.2 Gantt Chart that involves BDP 1 and BPD 2.

No.	Task	PSM1														PSM2													
	Weeks	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14	W1	W2	W3	W4	W5	W6	W7	W8	W9	W10	W11	W12	W13	W14
1	Finding the project that want to proposed.																												
2	Project Title Conformation and Registeration																												
3	Briefing with Supervisor																												
4	Study the Project Background																												
5	Drafting Chapter 1: Introduction																												
6	Task progress evaluation 1																												
7	Drafting Chapter 2: Literature Review																												
8	Table of Summary Literature Review																												
9	Drafting Chapter 3: Methodology																												
10	Work on the Software/Hardware																												
11	First Draft submission to Supervisor																												
12	Task progress evaluation 2																												
13	Submisiion Report to the Panel																												
14	Presentation of BDP1																												
15	Drafting Chapter 4: Analyse Data and Result																												
16	Data Analyse and Result																												
17	Record the Result																												
18	Drafting Chapter 5: Conclusion and Recommendation																												
19	Compiling Chapter 4 and Chapter 5																												
20	Submit Latest Report to Supervisor																												
21	Finalizze the Report																												
22	Presentation of BDP2																												

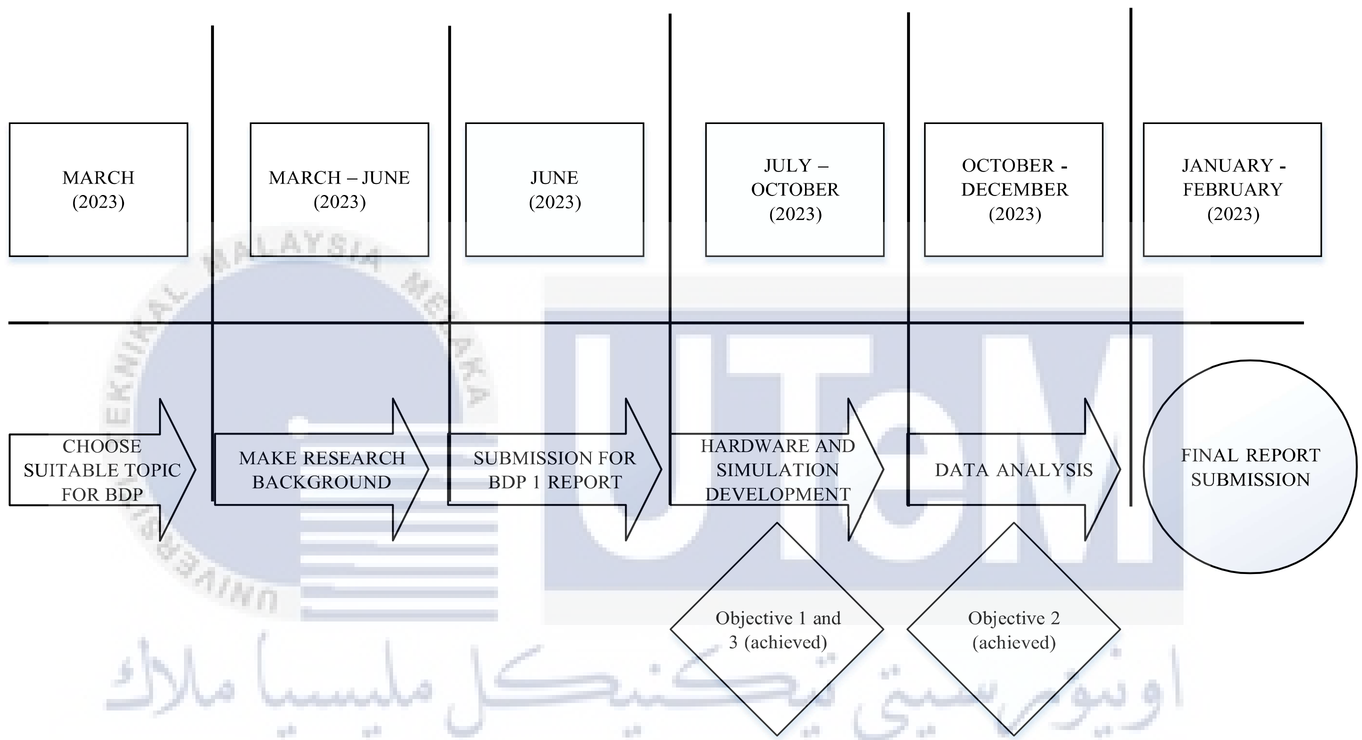


Figure 3.14 The milestone and journey of this project during BDP 1 and 2.

3.13 Summary of this chapter

This chapter 3 is about the method how does the project is going to build which involves the flowchart project that divided into 3 part which is the main flowchart, software project and hardware flowchart which explain the flow of the process of this VAWT system. Next, it also talks about the hardware material and components that are required to combine with hardware working process and simulation circuit that make the project able to build successfully. Besides that, the Gantt Chart and the milestone is created to show the journey and the achievement objective of this project which during BDP 1 and BDP 2.

For the next chapter, the project idea will focus heavily on data analysis results for both hardware and software to get the outcomes that match with project objectives.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results and analysis on the voltage and current reading produced by the old motor from the vertical-axis wind turbine (VAWT) that will display in digital multimeter.The data collected will might be different since the material of the wind blade is changed and being tested.Besides that, Next, there is a different between for the simulation circuit is create to analyse and determine speed rpm (m/s) for the VAWT to rotate with constant speed of the generator.

4.2 Discussion and analysis of simulation result

From figure 4.1, it can be observed that the value of wind speed (m/s) will have a significant impact toward the output speed (rpm) of the VAWT when running the system in wind speed of 20 m/s As for the hypothesis it can be stated that the higher the wind speed (m/s), the faster the speed (rpm) of the VAWT to be rotated which it will automatically produce a great amount of output power.

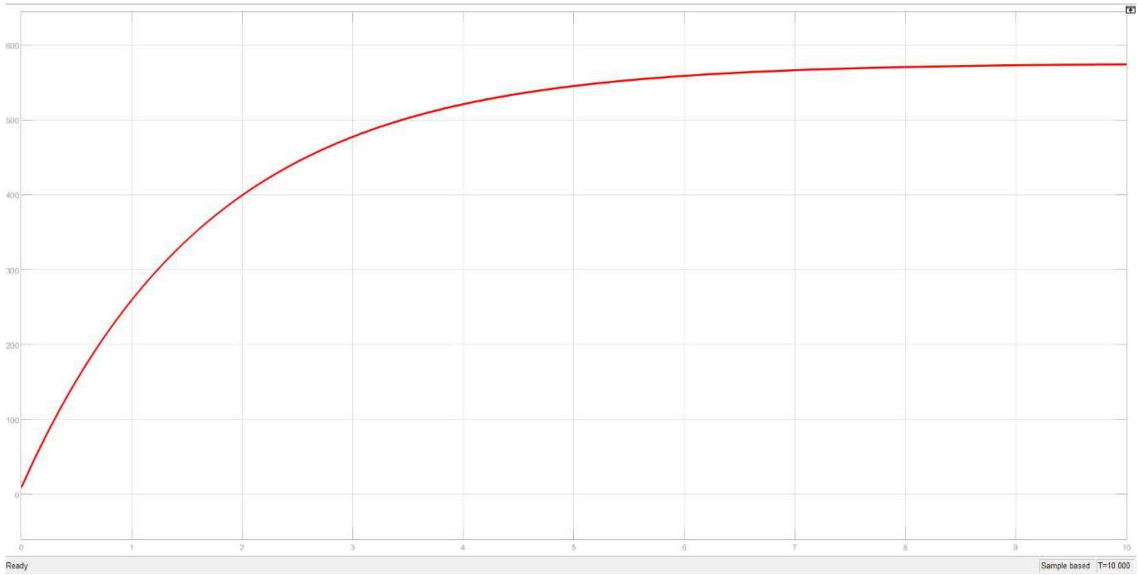


Figure 4.1 Graph of the rotation speed (rpm) when the wind speed is 20(m/s)

4.3 Discussion and analysis for hardware result

The analysis of this project is mostly focused on the performance of the VAWT in terms of harvesting energy. The data for AC voltage, DC current, and DC current had been collected with different types of wind blade to make sure which material will provide better efficiency. Thus, there is also an analysis on the various types of effects that cause the wind turbine performance to drop.

4.3.1 Data and analysis for wind blade PVC (D) material (No-load)

Table 4.1 PVC Class D information based on dimension, sizing and weight

Name of Material	Length(m)	Width (m)	Diameter (m)	Average Weight (kg)
PVC Class D	0.09	0.07	0.1016	0.92

Table 4.2 Show the all the data that have been produced from VAWT for 10 trial using PVC Class D

DATA	Wind Speed (m/s)	AC Voltage (v)	DC Current (mA)	DC Voltage + boost converter (v)
1	19.3	0.23	12.45	0.31
2	19.8	0.42	13.73	0.46
3	20.2	0.60	14.52	0.64
4	20.5	0.64	14.79	0.68
5	21.2	0.75	15.78	0.79
6	21.4	0.82	17.23	0.86
7	21.5	0.85	17.51	0.92
8	21.6	0.90	18.32	0.95
9	21.7	0.93	18.53	1.14
10	21.8	1.00	20.00	1.24

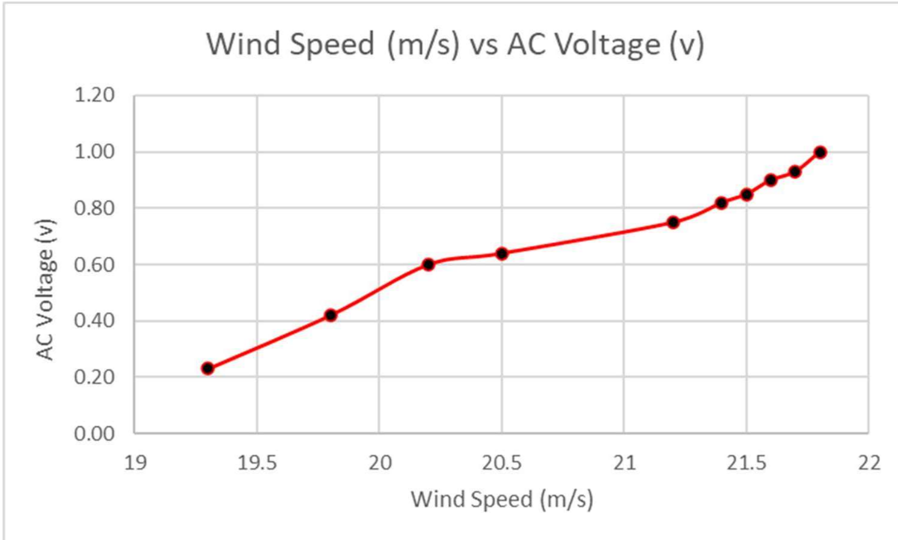


Figure 4.2 Graph of wind speed (m/s) vs AC voltage (v) for PVC Class D

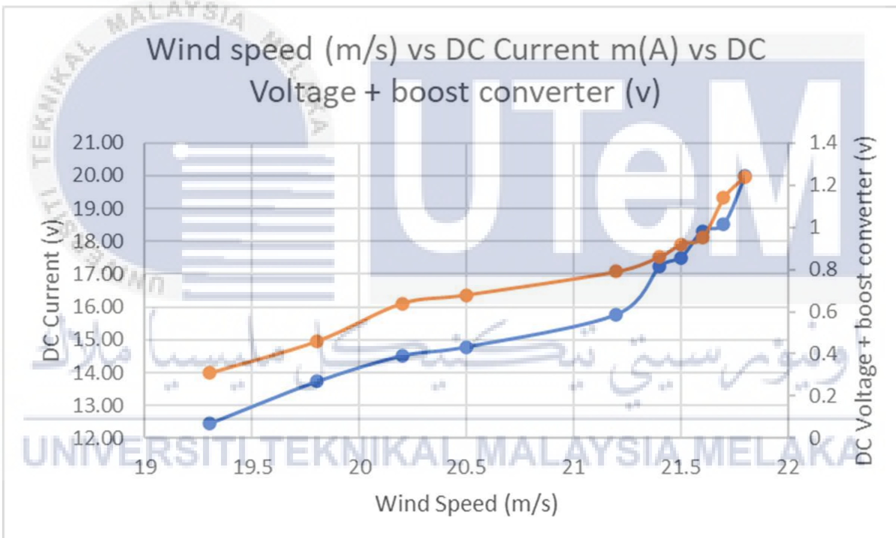


Figure 4.3 Graph of wind speed (m/s) vs DC current (mA) vs DC volatge+boost converter (v) for PVC Class D

Based on figure 4.2, as the wind speed (m/s) increases, the value of AC voltage produced by VAWT is also increases that conclude that wind speed (m/s) is increase proportional to the AC voltage.This is due to the kinetic energy given to the wind blade increases with wind speed , which turn the generator of turbine to rotate faster.The AC voltage produced by using this PVC as wind blade approximately below 1v which can be considered very low output.

Based on figure 4.3, DC current (mA) that produced from the rectfiier circuit is increases proportional to wind speed (m/s) that can reach up to 20mA while the DC voltage that have been boost by the converter also increases which reach until 1.24v.In addition, the boost converter also doest help so much since the input voltage is very low.

To conclude, this happen is due to the weight of the PVC Class D which is very heavy that give impact to the overall efficiency of the turbine and increase stress on other components. Besides that, the design challenges also one the main problem since the thickness for this PVC very difficult to be shape that lead to inefficient energy conversion and the "C" shape design that reduced the turbine performance.

4.3.2 Data and analysis for wind blade using aluminium flat sheet material (No-load)

Table 4.3 Aluminium flat sheet information based on dimension, sizing and weight

Name of Material	Length (m)	Width (m)	Diameter (m)	Average Weight (kg)
Aluminium flat sheet	0.13	0.12	0.09	< 0.001

Table 4.4 Show the all the data that have been produced from VAWT for 10 trial using aluminium flat sheet

DATA	Wind Speed (m/s)	AC Voltage (v)	DC Current (mA)	DC Voltage + boost converter (v)
1	19.3	1.52	23.43	2.15
2	19.8	1.56	24.02	2.19
3	20.2	1.59	24.53	2.34
4	20.5	1.64	25.31	2.37
5	21.2	1.67	26.32	2.84
6	21.4	1.70	26.45	2.96
7	21.5	1.73	27.04	3.22
8	21.6	1.79	27.43	3.41
9	21.7	1.81	28.41	3.53
10	21.8	1.84	28.53	3.82

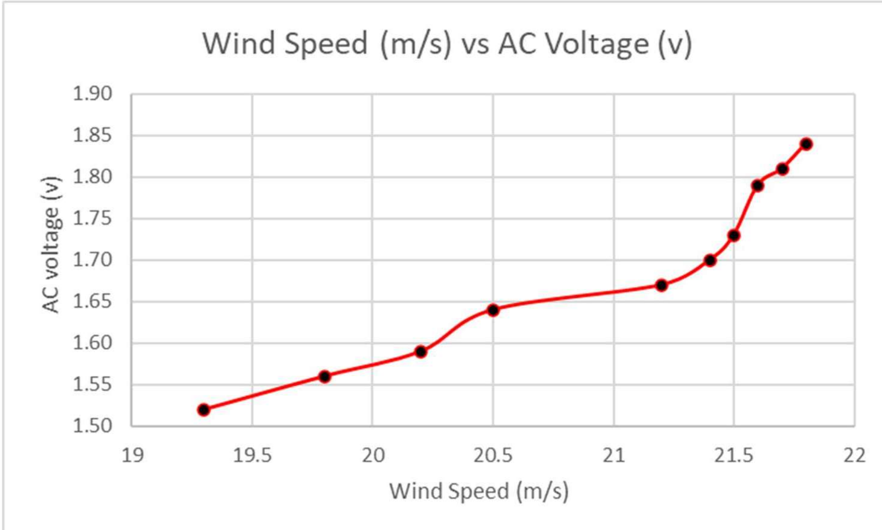


Figure 4.4 Graph of wind speed (m/s) vs AC voltage (v) for aluminium flat sheet

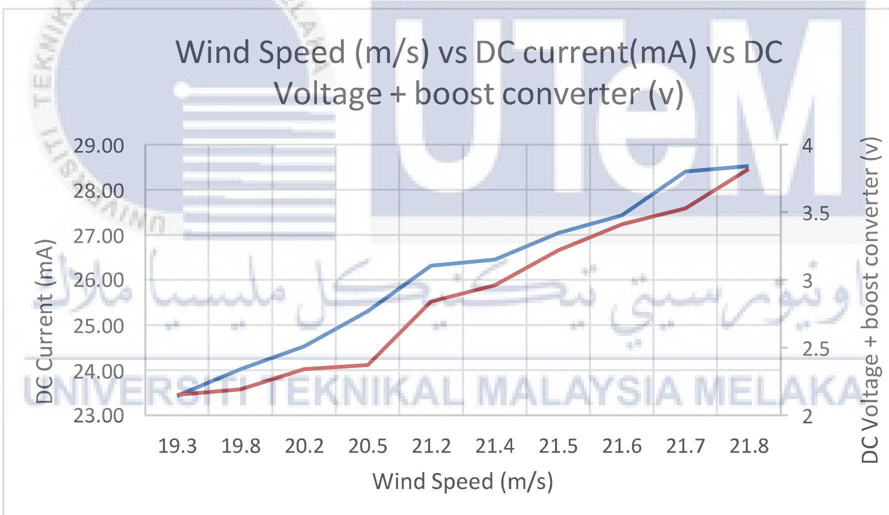


Figure 4.5 Graph of wind speed (m/s) vs DC current (mA) vs DC Voltage + booster (v) for aluminium flat sheet

Based on figure 4.4, as the wind speed (m/s) increases, the value of AC voltage produced by VAWT is also increases that conclude that wind speed (m/s) is increase proportional to the AC voltage. The AC voltage produced by using this aluminium flat sheet higher than 1v and almost reach 2v compared when using the PVC Class D.

Based on figure 4.5, DC current (mA) that produced from the rectfiier circuit is increases proportional to wind speed (m/s) that can reach up to 28mA while the DC voltage that have been boost by the converter also increases that can reach until 3.8v.In addition, the boost converter also help a little bit but can be impoved when using other type of material.

To conclude, this happen is due strength and flexibility of the aluminium sheet.Based on the observation and analysis, Wind turbine blades need to be strong and flexible to efficiently capture wind energy while enduring the dynamic forces, including bending and twisting.When the wind from the blower fan is very strong, the wind blade cannot withstand the strong wind as it will keep bending as wind direction will not be able to move synchronize with the wind blade as a result it will effect the performance of the wind turbine.Besides that, the "C" type design wind blade is not very efficient to the rotation of the wind turbine since the wind came from the blower only focusing on the center of the blade.

4.3.3 Data and analysis for wind blade using UPVC material (No-load)

Table 4.5 UPVC details information based on sizing and weight

Name of Material	Length (m)	Width (m)	Diameter (m)	Average Weight (kg)
UPVC	0.25	0.12	0.07	0.002

Table 4.6 Show the all the data that have been produced from VAWT for 10 trial using UPVC

DATA	WIND SPEED (m/s)	AC Voltage (v)	DC Current (mA)	DC Voltage + boost convertor (v)
1	19.3	1.50	80.20	8.54
2	19.8	1.59	94.73	9.84
3	20.2	1.87	105.86	10.57
4	20.5	1.89	135.33	10.83
5	21.2	2.34	146.76	11.08
6	21.4	2.36	164.42	11.1
7	21.5	2.44	174.73	11.12
8	21.6	2.48	178.12	11.15
9	21.7	2.54	182.82	11.17
10	21.8	2.58	191.22	12.4

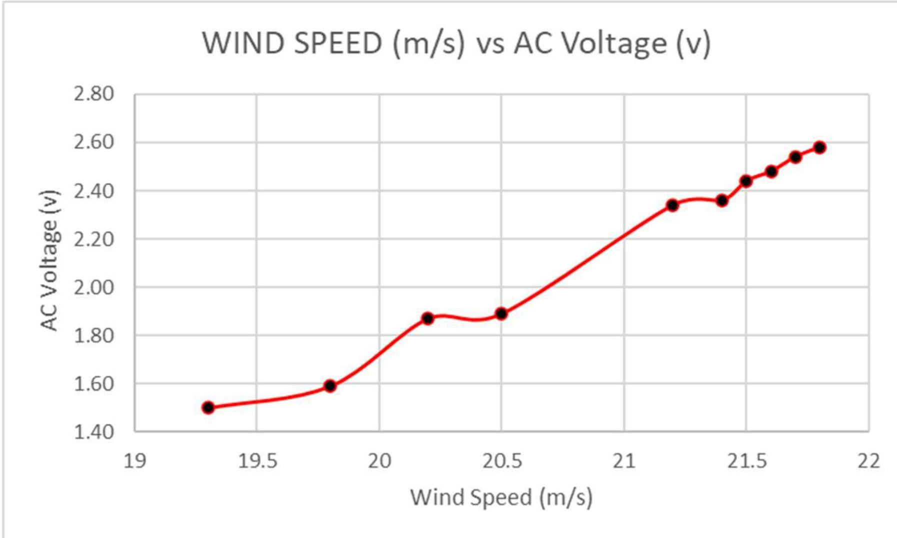


Figure 4.6 Graph of wind speed (m/s) vs AC voltage (v) for UPVC

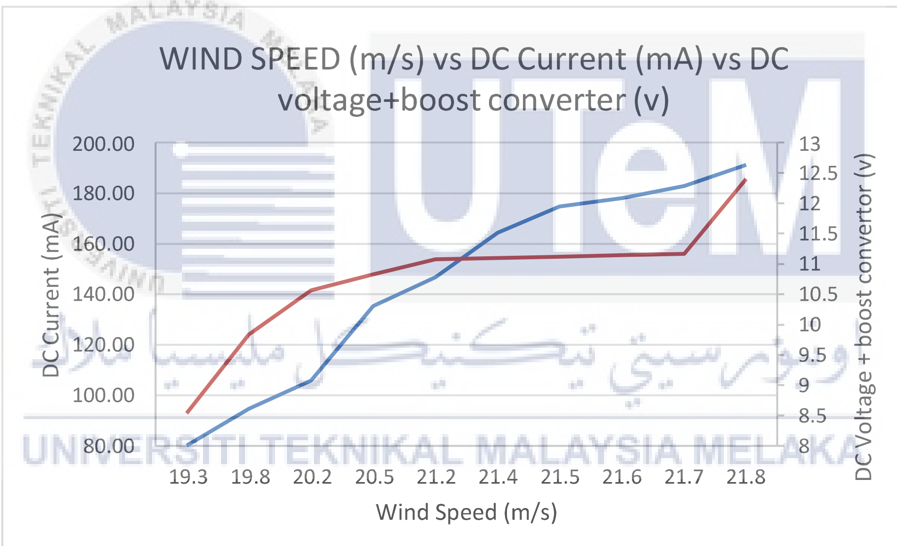


Figure 4.7 Graph of wind speed (m/s) vs DC current (mA) vs DC Voltage + booster (v) for UPVC

Based on figure 4.6, as the wind speed (m/s) increases, the value of AC voltage produced by VAWT is also increases that conclude that wind speed (m/s) is increase proportional to the AC voltage. The AC voltage produced by using this UPVC provide higher initial output which is from 1.58v until it reaches the maximum value which 2.58v.

Based on figure 4.7, DC current (mA) that produced from the rectfiier circuit is increases proportional to wind speed (m/s) that can reach up to 191mA while the DC voltage that have been boost by the converter also increases that can reach until 12.4v.In addition, the boost converter contribute very high impact toward the voltage value when compare it to other type of materials.

To conclude, UPVC is a material that is very suitable to be used as a wind blade because its impact on the performance on the wind turbine is very efficient.This is due to the strength and flexibility of the UPVC material where it made from hard material that can withstand the strong wind from the blower.Therefore, the rotation of the wind turbine becones better since it synchronize with the direction of the wind.Besides that, the aerodynamic design wind blade allow it can provide better control over turbine performance.

4.3.4 Data and analysis for wind blade using UPVC material (load)

Table 4.7 Show the all the data that have been produced from VAWT for 10 trial using UPVC

DATA	WIND SPEED (m/s)	AC Voltage (v)	DC Current (mA)	DC Voltage + boost convertor (v)
1	19.3	1.50	12.60	3.13
2	19.8	1.59	14.43	3.24
3	20.2	1.87	15.41	3.42
4	20.5	1.89	17.42	3.53
5	21.2	2.34	17.89	3.58
6	21.4	2.36	18.94	3.61
7	21.5	2.44	19.22	3.74
8	21.6	2.48	19.43	3.82
9	21.7	2.54	19.84	3.86
10	21.8	2.58	20.14	4.04

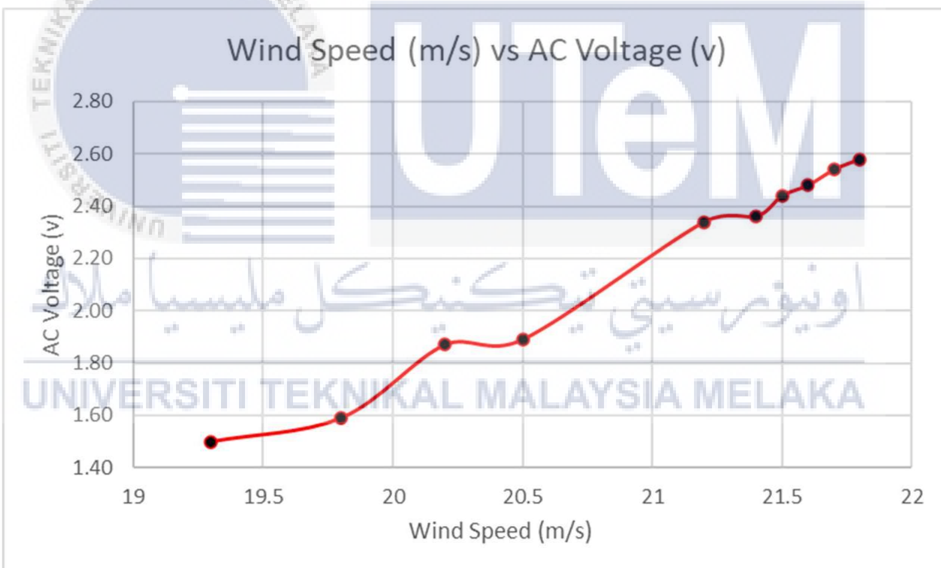


Figure 4.8 Graph of wind speed (m/s) vs AC voltage (v) for UPVC when connected to the solar charger controller

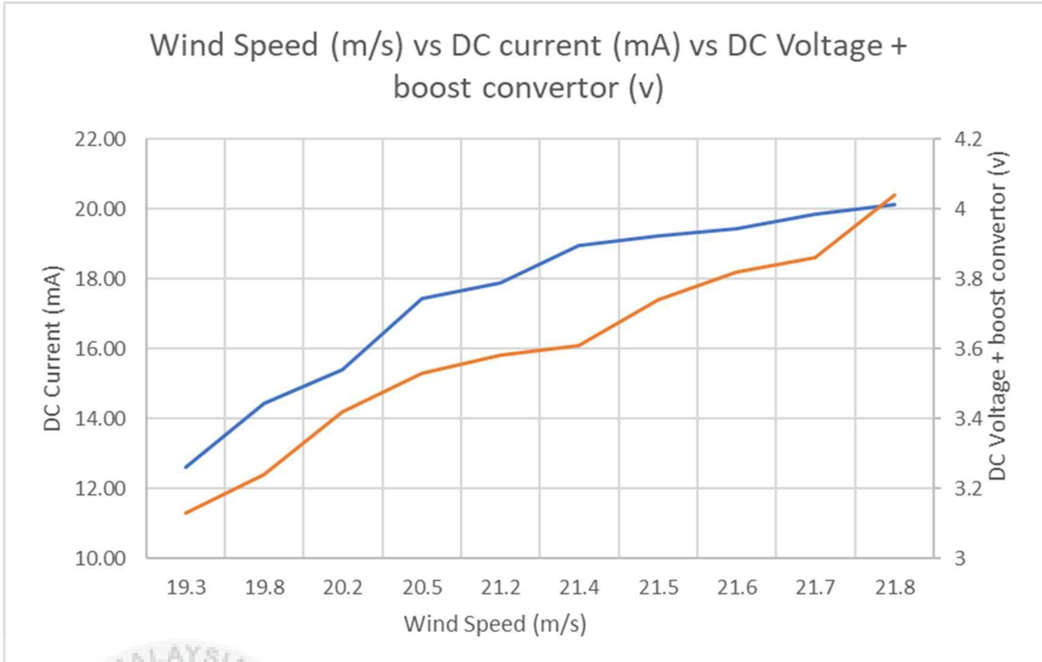


Figure 4.9 Graph of wind speed (m/s) vs DC current (mA) vs DC Voltage + booster (v) for UPVC when connected to solar charger controller

Based on figure 4.8, as the wind speed (m/s) increases, the value of AC voltage produced by VAWT is also increases that conclude that wind speed (m/s) is increase proportional to the AC voltage. The AC voltage produced by using this UPVC provide higher initial output which is from 1.58v until it reaches the maximum value which 2.58v.

Based on figure 4.9, DC current (mA) that produced from the rectfiier circuit is increases proportional to wind speed (m/s) but the current drop significantly up to 20mA which also the same cases to the DC voltage as it produced within the range of 3v – 4v.

To conclude, the reason why the voltage drop is can be due to the mistmatched power ratings.Therefore, voltage drop problems can occur in the system if the power ratings of the wind turbine and the load are mismatched. For example, if the load wants more electricity than the wind turbine can provide at a particular wind speed, the voltage may drop.Besides that, higher cable resistance is also lead to the voltage drop plus the connector.

4.4 Summary of this chapter

This chapter tells about VAWT that has been tested with various types of materials especially on wind blade design to get which material get the better performance in terms of harvesting the energy, the effect of wind speed (m/s) to the wind turbine output and the performance of old motor turn into generator.

For the next chapter, it finally about the conclusion of this project during BD1 and BD2 and the potiential of being commercialization especially in marketing sector.The future work is also will be explained as a improvement for this project to be develop in the future.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

As a conclusion, this project came up with new ideas which is the ability to use the wasted materials and components that can convert it into something very useful application such as the VAWT that is very clean, environment-friendly, and free fuel. Furthermore, a few articles state that VAWT is very suitable to build in blower applications because the wind speed from the blower fan that mostly been installed in industry was very strong that make it suitable to be build for harvesting the energy.

Based on all the result had been taken, it is clear that when the wind speed (m/s) is increase, the output produced by the wind turbine also increases that make the performance of the wind turbine become better that make project objective 1 had been achieved.

Next, the project objective 2 also achieve when the old motor which is the permanent magnet synchronous motor can turn into generator that convert kinetic energy into electrical energy by excitation field generated from the permanent magnet.

Besides that, UPVC can harvert more energy than the PVC Class D and the aluminium flat sheet.Besides that, the UPVC is the only material that can light up the solar charger controller which make the project objective 3 had been achieved.In addition, the wind turbine also experience the voltage drop due to the power rating of the wind turbine and the load plus the cable resistance.

5.2 Potential for Commercialization

The project's vertical-axis wind turbine (VAWT) holds significant potential for commercialization as it incorporates a comprehensive set of design optimizations and innovative features. With its aerodynamically efficient blade design, lightweight yet durable materials, the VAWT demonstrates improved energy capture across a wide range of wind speeds. Therefore, this project has the potential to be placed in an industrial factory that has a blower machine and the wind is very fast without depending on the weather factor when compared to solar panels. In addition, with its small size it is so easy to place it in the blower room and small to be able to harvest energy from it being wasted.

5.3 Future Works

For future improvements, accuracy of VAWT results could be enhanced as follows:

i) High torque motor that required low wind speed to produce high output voltage.

ii) Using higher wind speed (m/s) that more 20 m/s for better performance of VAWT.

iii) Adding the multiple blade can improve torque and stability especially on low wind speeds.

iv) Adding the damping mechanism which can reduce the vibrations and oscillation of VAWT.

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