DEVELOPMENT OF MICRO AIR FLOW GENERATOR FOR ELECTRICAL CHARGING SYSTEM

by

Ahmad Saufi bin Ahmad Shabri

Dissertation submitted in partial fulfillment of

the requirements for the

Bachelor of Engineering (Hons)

(Electrical & Electronics Engineering)

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CERTIFICATION OF APPROVAL

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Electrical & Electronics Engineering Programme
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Approved by,

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Project Supervisor

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TRONOH, PERAK

September 2011

CERTIFICAL OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgement, and the original work contained herein have not been undertaken or done by unspecified sources or persons.

AHMAD SAUFI BIN AHMAD SHABRI

ABSTRACT

The need for electrical energy nowadays is high. As technology becomes advanced in certain areas, the ability to produce power has had to keep pace with the increasing of demands. There is a tremendous amount of free energy in the air or wind which is available for energy conversion. The use of wind machines to harness the energy in the wind is not a new concept. The early machines were used for pumping water for irrigation purposes and later developed as windmills for grinding grain. The power in the wind at any moment is the result of a mass of air moving at speed in a particular direction. Thus, the electric power generation technology these days being highly develop. Since motorcycles are the main vehicle used in Malaysia, a charging device is not available compare to cars which have a cigarette port as charging port. Aware on free energy produced by air flow in the motorcycle exhaust, it can be utilized to produce electricity. Having a concept of wind generator, this air flow energy can be exploited. Therefore, the aim of this project is to generate electricity through the conversion of wind energy to electrical energy. The methods used are to develop a turbine for energy harvester, a DC generator for electrical generation and an electrical circuit to boost the output produced by the generator. The air flow is being converted into kinetic energy by the rotation of a turbine. Attached to the turbine is the shaft and directly into the DC motor. Inside the motor, there are two main components which are permanent magnet (stator) and winding (rotor). The rotation of the shaft makes the rotor move and then the motor will react as the generator. From these consequences, the generation of electricity energy can be produced. Then, prototype being developed consists of the turbine, the casing of the turbine, DC generator and electrical circuit. Several testing then being conducted to see the performances and output of the prototype. By having a rechargeable battery, electrical energy can be stored. Target of this prototype is to produce 5V for charging purpose. This electrical energy then can be used for any type of application, such as charging the hand phone, mp3 player and even digital camera.

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LIST OF ABBREVITIONS

AC	Alternating Current
DC	Direct Current
e.m.f	Electromagnetic Force
HAWT	Horizontal Axis Wind Turbine
PMDC	Permanent Magnet DC Motor
rpm	Revolution per Minutes
TSR	Tip Speed Ratio
VAWT	Vertical Axis Wind Turbine

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Wind energy is a renewable and free energy. Wind is a form of solar energy. Winds are caused by the uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are modified by the earth's terrain, bodies of water, and vegetative cover. This wind flow, or motion energy, when "harvested" by modern wind turbines, can be used to generate electricity.

An air flow from the motorcycle's exhaust is also can be considered as a source of this kind of energy. By taking the concept of wind generator, it is possible to implement a small scale of air flow generator to be used in motorcycle exhaust's system. For this project, a small turbine being design to harness the air flow to create a kinetic energy. This kinetic energy is transfer into the shaft of the turbine to the motor. Having a kinetic energy, it will form a mechanical energy to the motor. A motor that have a mechanical energy as the source make it operates as a generator. This generator can generate electricity and then being stored into a rechargeable battery for future use.

Designing an air flow generator in motorcycle exhaust's system, the main aspect that impact the production of power generated is the air flow rate. Higher the air flow rate will cause the power generated to be high. In motorcycle's exhaust system, the air flow rate is depending on speed of the motorcycle. The lowest air flow rate of the exhaust is when the motorcycle is in static or not moving. When the motorcycle starts to move, the air flow rate will be higher.

The most important things to design this generator, type of turbine and generator need to be considered. The selection of these two criteria will determine the performance of the generator. In this project, a Savonius type of turbine is used to harness the air flow and permanent magnet DC motor as the generator to be used for suitability of it application.

1.2 Problem Statement

Motorcycle is one of preferable transportation in Malaysia. Compare to a car, motorcycle do not have any device or element of charging purposes. Most development of electrical technology is more on car. Normally, a car users do not having a problem if they running out of battery for their electrical device such as hand phone, mp3 player or etc. But, for motorcyclist, they do not have any option if their hand phone is running out of battery.

For an emergency case, such as the user of the motorcycle involve in incident like his motorcycle broke down in the middle of highway and yet his hand phone is low in battery, he might having trouble to make a call. So, it is a good idea to make a small scale of generator for motorcycle user so that it fit the demand of electricity consumption. Having this small generator, his hand phone can be charged when he ride his motorcycle.

Not only for some emergency cases, this small generator also can charge other electrical devices. Nowadays, people tend to have his/her electrical devices in fully charged so that they can optimize the function of the device. Hence, this small scale generator in motorcycle exhaust's system is very useful and meets or satisfies the people needs.

1.3 Objectives

The main objective of this project is to design and develop a prototype of micro air flow generator in motorcycle's exhaust for electrical charging system. Besides, other objectives are:

1. To make a literature review on the electrical generator technology.
2. To harness the air flow energy to produce electricity for charging.
3. To develop a device which are portable, environmental and user friendly.
4. To conduct testing on the completed prototype for results and performances.

1.4 Scope of Study

For the scope of study, the elements are consisting of the literature review, methodology, results and discussion, and conclusions with recommendations. Each of these elements will be discussed in details in following chapters.

In literature review, things that being deliberate is about technology of wind generators, study on turbine, DC motor and DC-DC converter. Throughout this chapter, details elaboration being focused related to the project. From the big idea of wind generator, the concept then lead to the objective to develop the micro air flow generator.

To achieve this objective, method and approach need to be identified. First step is to planning the work for the whole two semesters. Then, from the conceptual design of the generator, a proposed design will be come out. From this design, fabrication process then is followed up. After the fabrication is done, the next step is to do a testing on how the prototype operates. In chapter four, the results of these tests will be analyzed. Further discussion on the results then deliberated to conclude the performance of the prototype.

Under conclusions and recommendations, author concludes the whole things on this report and gives some recommendation in order to improve the performance of this prototype for future work.

CHAPTER 2

LITERATURE REVIEW

In designing a micro air flow generator, a basic concept used is wind generator system. The technology used in wind generator in generating electricity will be included in this chapter. Theory studies and analyzes on previous and present wind generator technology will be stated. Then, a several research on turbine, DC motor as generator, and DC-DC converter are conducted for gather information in developing micro air flow generator.

2.1 Previous Design and Technology

An early middle ages, wind power is being as a windmill. A windmill is a machine which converts the energy of wind into rotational energy by means of vanes called sails or blades. Originally windmills were developed for milling grain for food production. In the course of history, the windmill was adapted to many other industrial uses [1]. The first practical windmill had sails that rotated in horizontal plane, around a vertical axis. Then, they come out with vertical windmills.

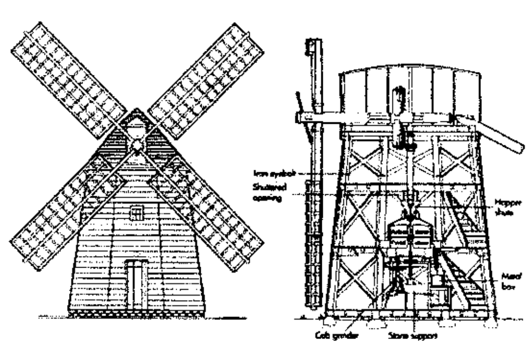

Figure 1: Vertical windmill design [2]

Then, after the middle ages, a wind power is used for wind pumps. A wind pumps is a windmill used for pumping water.

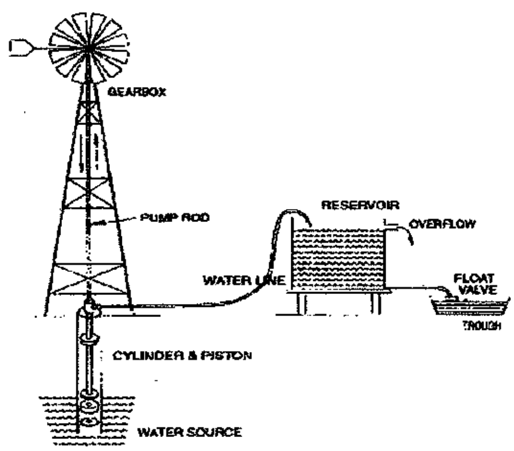

Figure 2: A wind pumps design [3]

As time goes, they create a wind generator. Wind generator is a device that can generates electrical power from the energy of wind. Wind generator has traditionally been wind turbines, i.e. a propeller attached to appropriate electronics to attach it to the electrical grid or to charge batteries. Recently, however, a reciprocating non-turbine wind generator, the wind belt, has been invented. It promises to reduce the cost for generating small amounts of power tenfold. Wind generators have become very popular lately as mean as to generate power for home consumption. Large installations of wind generators can run entire towns. Wind generators come in many different sizes and shapes from vertical model, horizontal and even rooftop model.

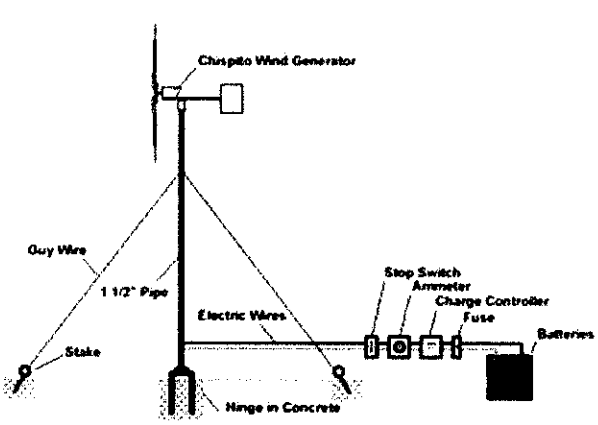

Figure 3: A wind generator design [4]

With this wind generator concept, technology then enhance to generation of wind farm. Wind farms are used to generate large amount of electric power when multiple wind turbines are placed in the same location. Basically, a large wind farm may consist of many separate wind turbines and the land between the turbines mostly used for agricultural or other purposes. There are two possibility location of wind farm, either installed onshore or offshore.

Figure 4: Onshore wind farm in England. [5]

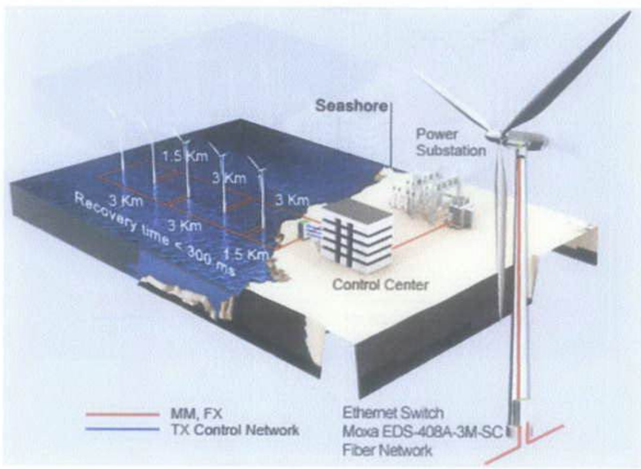

Figure 5: Offshore wind farm. [5]

In Malaysia, wind energy conversion (WES) is serious consideration since the potential for wind energy generation depends on availability of the wind that varies with location. Mostly in resort islands on the East Cost in South China Sea have great potential of wind energy conversion. Aware of this potential of the harvesting the wind energy, Malaysia Government under joint venture partnership with the State Government of Terengganu and National Electric Board in 2007 embarks on the project of integrating power supply at Pulau Perhentian (Perhentian Island). The project consists of installing two wind turbines, solar farm, generator and battery [6].

Figure 6: Wind turbine at Pulau Perhentian. [6]

Not only in Pulau Perhentian, the development of wind farm also has arisen in Kudat, Sabah. There, Green Constitute Sdn. Bhd. (GCSB) already funding money for development of 100MW wind farm to produce electricity power.

Classification of wind generator is based on its wind turbine. Two types of wind turbine is vertical and horizontal axis wind turbine. In large scale of wind generator, mostly horizontal axis wind turbine is used because it will generate more electricity. It is because horizontal axis wind turbines have greater coefficient of performance which means that the efficiency of the generator is high.

2.2 Distribution of air

In mixing ventilation, wall jets are extensively used for supply of ventilation or conditioned air to rooms and spaces. A wall jet is a stream of fluid blown tangentially along a wall and it has a wide range of applications, such as film cooling on wind turbine, boundary-layer separation control over a wing and etc. Before the air enters the occupied area of the room velocities and temperature differences must have decreased to an acceptable level.

From room with small characteristic dimensions (*W/H* <2, *L/H*<3), where *W*, *L*, and *H* are width, length and height of the ventilated space, the wall jet undergoes a number of deflections at the corners it meets during its course from the supply to the floor. When the jet is approaching an opposing side (room corner), an adverse pressure gradient is built up and jet "restart" again [7].

When the ratio *L/H* is larger than a certain value, environment implies that air must be led back along the floor and this will disperse the jet. The distance from the wall with the inlet to the stagnation point where the flow diverges is called penetration length l_{re}, see *Figure 7*. The penetration length is a significant parameter for proper air distribution design. At a distance from the supply opening which is larger than l_{re}, the velocity is very low since the supply air is distributed over the whole cross area, while the velocities are very high at a distance smaller than l_{re} because large volume of air is set into motion by the entrainment below the wall jet.

For a normal room the ventilated section should always be smaller than the calculated penetration length so a rotary air flow pattern can be established. However, some application, such as mining tunnels, requires a penetration length as long as possible.

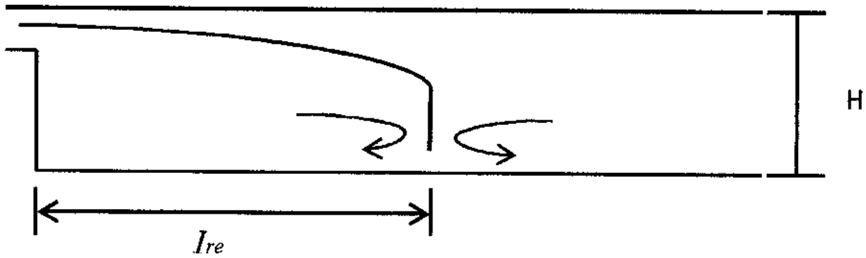

Figure 7: Penetration length of long room. [7]

2.3 Wind Turbine

To construct a wind generator, one of the main elements is a wind turbine. A wind turbine is a device that used to transform kinetic energy from the wind into the mechanical energy in shaft and finally into electrical energy in a generator [1]. It is necessary to know various type of wind turbine in order to choose the best type to be fit in this project. In addition, the characteristic of each type of the turbine need to be studied so that the finest design of the turbine can generate the greatest electricity. However, a wind turbine cannot capture all kinetic energy in wind and a good energy conversation system converts about 25% into useful power [8]. This is proportional to the swept area of the rotor and the cubic average wind speed at the center of the rotor.

Although there are many different configurations of wind turbine, most of them can be categorized into two classed based on the orientation of the rotor. The first category is Horizontal-Axis Wind Turbine (HAWT). This type of wind turbine is the most commonly used in producing electricity for wind generator. HAWT have the main rotor shaft and electrical generator at the same level and must be pointed into the wind [9]. Another one type of wind turbine is Vertical-Axis Wind Turbine (VAWT). VAWT has the main rotor shaft arranged vertically. Having this kind of wind turbine, the arrangement of the turbine does not need to be pointed into the wind to be effective.

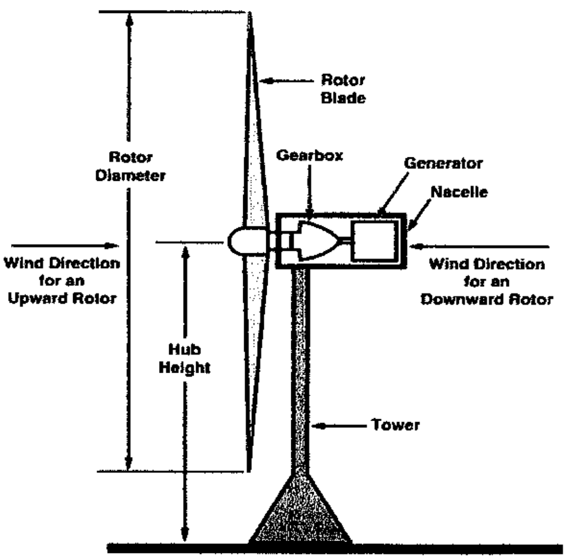

Figure 8: Horizontal-axis wind turbine [9]

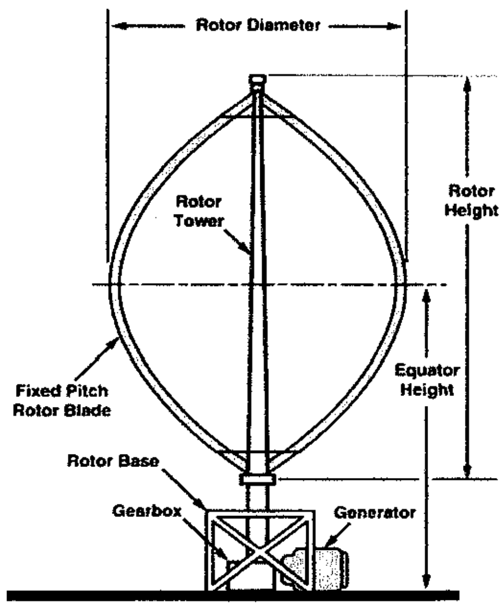

Figure 9: Vertical-axis wind turbine [9]

Even most of wind turbines are of the horizontal axis type, but vertical axis wind turbines or VAWTs have some advantages for direct mechanical drive applications. They need no tail or yaw mechanism to orient them into the wind and power is easily transmitted via a vertical shaft. Wind turbines with a vertical axis represent a valid alternative to horizontal axis one, particularly for household application. Even though vertical axis rotors are being said for their minor efficiency with respect to horizontal axis rotor, they are characterized by smaller dimension and would be preferred in small and medium power application. An important aspect to be underlined is that vertical axis wind turbines have a better power generation capability even in low wind speed. Thus, Vertical-Axis Wind Turbine (VAWT) is being chosen for this project as the wind turbine type.

2.3.1 Subtypes of VAWT

For vertical-axis wind turbine, we have several basic designs. The designs are:

1. Savonius turbine.
2. Darrieus turbine.
3. Noguchi.
4. Helical.

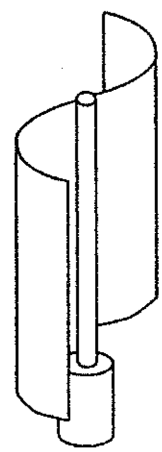

Figure 10: Savonius turbine [10]

The characteristics of Savonius turbine are:

- Based on drag force type of rotor.
- Can be implemented in high torque input.
- Having a low speed (rpm) rotation of rotor.

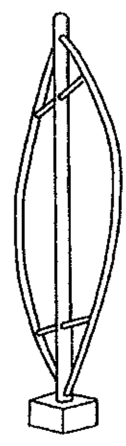

Figure 11: Darrieus turbine [10]

The characteristic of Darrieus turbine are:

- Based on lift force type of rotor.
- Can be implemented in low torque input.
- Having a high speed (rpm) rotation of rotor.

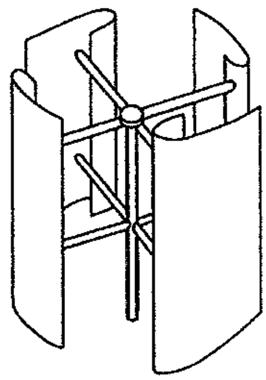

Figure 12: Noguchi turbine [10]

The characteristic of Noguchi turbine are:

- Based on drag force type of rotor.
- Can be implemented in high torque input.
- Focused on low speed (rpm) rotation of rotor.

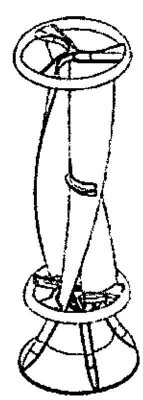

Figure 13: Helical turbine [10]

The characteristic of Helical turbine are:

- Based on drag and force type of rotor.
- Having foil section at every possible angle of attack.
- Produce a high speed (rpm) rotation of rotor.

In principle there are two different types of wind energy conversion devices: those which depend mainly on aerodynamic lift and those which use mainly aerodynamic drag [10]. Low speed device are mainly driven by the drag force acting on the rotor while high speed turbines rely on lift forces to move the blades. Savonius turbine is an example of drag type rotor and Darrieus turbine is an example of lift type rotor.

For a bigger scale of wind generator, it is known that to generate high electricity, high speed lift types of turbines are needed since the speed of the rotation turbine is proportional to amount of electricity produced. However, in order to make a small scale of wind/air-flow generator, Savonius type of rotor is the most suitable design although Savonius is a drag rotor type. Since the air volume in the exhaust is small, it is hard to harness air energy if use Darrieus rotor type. Despite, other advantages of Savonius design compared to other designs are:

1. Low rotating speed (which make them more silent).
2. Low cost and simplicity in construction.
3. High mechanical strength in case of high speed wind.

2.3.2 Rotor Design Parameter

Since already being stated that rotor type that will be used in this project is Savonius, it is necessary to know the parameters of the rotor. By knowing the parameters, it will be easier to design the rotor so that it will give higher efficiency and fully harness the energy from the air flow to be converted to kinetic energy and then generate it into electrical energy for storage.

In this section, a simple procedure for an approximate design of a wind rotor is discussed, based on the fundamental theories. Parameters are to be identified in this rotor design are radius of rotor, Tip Speed Ration (TSR) of the rotor, and number of blades.

The radius of the rotor is primarily depends on the power expected from the turbine and the strength of the wind regime in which it operates. Design tip speed ratio depends on the application for which the turbine is being developed. Low tip speed ratio is chosen for an application that need high starting torque while for application to generate electricity, it is required for a fast running rotor and hence high tip speed ratio needed. The number of blades in a rotor is directly related to the design of tip speed ratio. Higher the tip speed ratio, the lower would be the number of blades [11]. *Figure 14* gives a guideline for choosing the number of blades based on the design tip speed ratio.

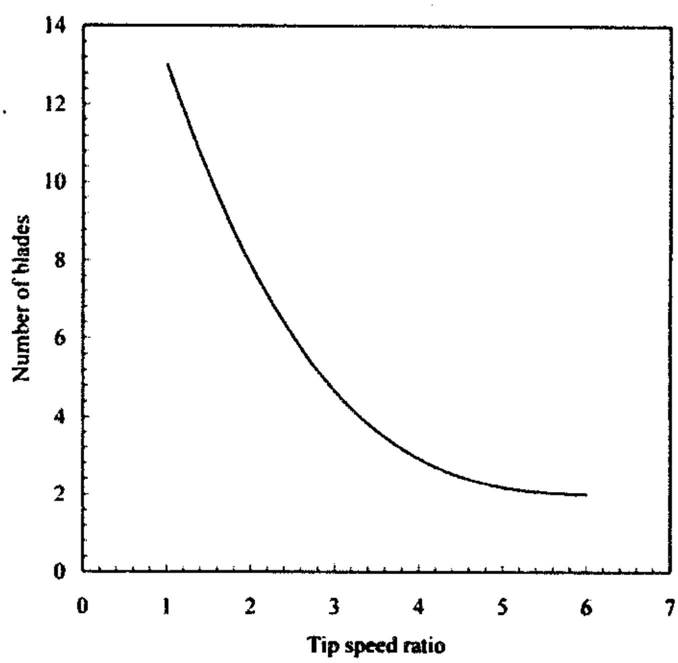

Figure 14: Number of blades versus Tip speed ratio [11]

Thus, relate it to the project, it is now clear that these parameters should need to be considered. Since the radius of the rotor is based on the exhaust dimension, this parameter is less to be manipulated. To get the high generated electricity, the tip speed ratio of the rotor needs to be high as possible. From *Figure 14*, the high tip speed ratio is when the number of blades is two. However, since the cross sectional area of the air flow is only attack half side of the rotor, two blades rotor is not suitable. So, the best option is to design the rotor with three blades.

2.4 Generator

Generator is the unit of the wind turbine that transforms mechanical energy into electrical energy. The blades transfer the kinetic energy from the wind into rotational energy in the transmission system, and the generator is the next step in the supply of energy from the wind turbine to the electrical grid [12]. There are two types of generator, which are AC generator and DC generator. For suitability of the project, a DC generator is being chosen since the objective of generating electricity is for charging purposes.

Compared to DC motor, there is similarity between DC motor and DC generator. The operation concepts of both machines are the same except the direction of the power flow and consequently current. Generators are driven by a source of mechanical power that is known as primary mover. In this project, wind or air-flow is the main source of the mechanical power. According to Faraday's Law, the induced e.m.f (electromotive force) generated due to relative movement of a circuit and a magnetic field is the phenomenon underlying electrical generator [13]. When a permanent magnet is moved relative to a conductor, or vice versa, an electromotive force is created. If the wire is connected through an electrical load, current will flow and thus electrical energy is generated, converting the mechanical energy motion to electrical energy.

In this world, there are many types of DC motor. They can be classified into several types. In general, types of DC motors are:

1. Separately excited DC motor.
2. Shunt DC motor.
3. Series DC motor.
4. Compounded DC motor.
5. Permanent magnet DC motor.

Except the permanent magnet DC motor, all these type of DC motor used a field winding to create a magnetic field. A permanent magnet motor does not have a field winding on the stator frame, instead relying on permanent magnets to provide the magnetic field against which the rotor field interacts to produce torque [14]. Compensating windings in series with the armature may be used on large motors to improve commutation under load. Because this field is fixed, it cannot be adjusted for speed control. Permanent magnet fields (stators) are convenient in miniature motors to eliminate the power consumption of the field winding.

Permanent magnet motors have some advantages compare to another type of motor. They are smaller in size, lighter, more efficient and reliable. Based on these advantages, permanent magnet motor is used for this project. In addition, there are four type of permanent magnet motor classified according to their field flux is produced. There are:

1. Permanent magnet DC motor (PMDC).
2. Permanent magnet brushless DC motor.
3. Permanent magnet brushless synchronous motor.
4. Permanent magnet stepper motor.

From these types, permanent magnet DC motor is chosen for this project for it suitability in term of its characteristics and advantages.

2.4.1 Advantages of Permanent Magnet DC Motor

Permanent magnet DC motors have a constant torque characteristic over the entire speed range. This type of DC motor has the following major advantages [15]:

1. No electrical energy is absorbed by the field excitation system and thus there are no excitation loses which means substantial increase in the efficiency.
2. Better dynamic performance than motors with electromagnetic excitation (higher magnetic flux density in the air gap).
3. Higher torque and/or output power per volume than when using electromagnetic excitation.
4. Simplification of construction and maintenance.
5. Reduction of prices for some types of machines.

2.5 DC-DC Converter

DC to DC converter is a well-known electronic device to convert a direct current (DC) source from one voltage level to another voltage level. In general, there are two types of DC to DC converter, which are:

1. Buck converter.
2. Boost converter.

Buck converter is used to reduce the dc voltage of the source and has a conversion ratio *M(D)*=D. For boost converter produces an output voltage that is greater in magnitude than the input voltage. Its conversion ratio is $M(D)=1/(1-D)$. Thus, boost converter is a DC converter that is needed to boost the voltage level from the power generated by the generator. Since there are losses in conversion of the kinetic energy to electrical energy, this type of converter is needed.

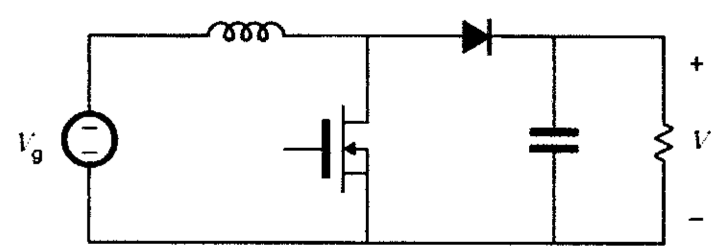

Figure 15: Simple circuit of boost converter.

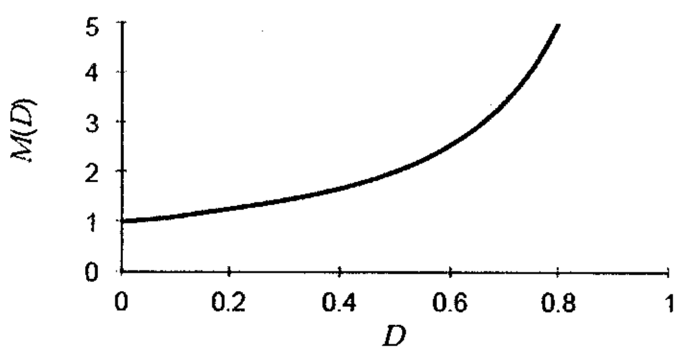

Figure 16: Characteristic of DC conversion ratio.

2.6 Power Conversion

Generating an electricity from the air generator, there must have a losses occurred in energy conversion. It is necessary to know the power conversion from the air flow energy to the end of the system. *Figure 17* below shows the power conversion chain of the wind system. The upper chain identifies the main conversion stages, while the lower boxes describe the losses occurring at each stage.

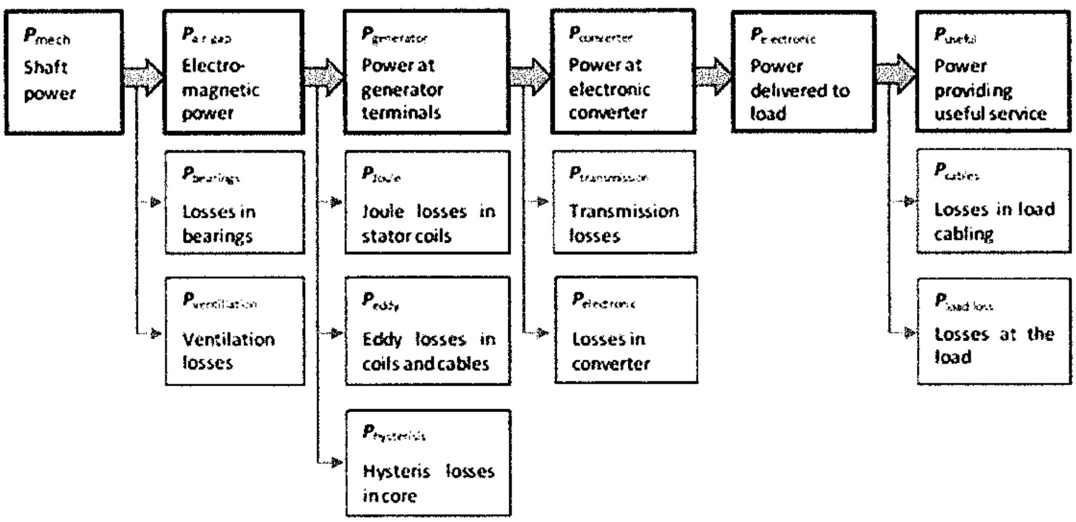

Figure 17: Power conversion chain.

2.7 Conclusion

It is understand that technology of wind energy is widely used even in early middle ages. From the windmill technology, it then developed to wind pump and come the idea of wind generator. The technology of wind generator itself is expanded into wind farm which can be seen installed in onshore or offshore. Using multiple of wind turbine located at the same place, it then will generate large amount of electricity power. Malaysia also not astern in this technology where in Pulau Perhentian itself do has wind farm technology.

From several type of turbine, Horizontal-Axis Wind Turbine (HAWT) and Vertical-Axis Wind Turbine (VAWT), VAWT type of turbine is chosen because of it suitability and advantages over HAWT. Since the air flow in the exhaust only in one direction, the VAWT type is more suitable. Savonius type of turbine of VAWT is chosen from other type of VAWT. For the turbine parameter, three blades of turbine is the best option to be designed to produce higher tip speed ratio.

Based on the information gathered about the technology of wind generator concept, several kind of turbine, type of DC motor, and boost converter, it is understood that to develop a prototype of air flow generator need all these components. Thus, the proposed conceptual design is shown in *Figure 18.*

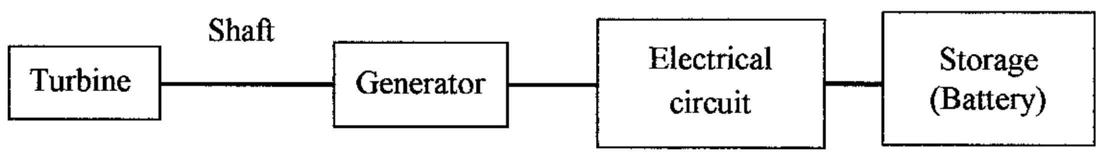

Figure 18: Conceptual design of micro air flow generator.

From the *Figure 18*, four main parts are turbine, generator, electrical circuit and storage. The turbine is used to harvest the air flow energy and then the shaft connected to the generator will make the generator rotates and electricity will be produced. Then, the electrical circuit that consists of booster will enhance the input voltage to higher value. This output will be stored in battery for storage or can be consume for charging electrical device.

CHAPTER 3

METHODOLOGY

In this chapter, methodology and approach are being discussed in order to attain the objective of this project. All the way through the two semesters, several activities had being done to accomplish from the work planning which displayed in Gantt chart (attached in Appendix A), fabrication process in laboratory and testing for prototype performances.

3.1 Research Activities

In the early stage of the project, research is being done to gather information, facts, theory and fundamental regarding the project. By studies the books, journal, internet and thesis, any relevance information is collected. This research is important to make more understanding on what the project is all about. There are two main parts of this project, which are mechanical part and electrical part.

For mechanical part, it is referred to the prototype itself that consists of turbine and generator. In this part, fabrication process needs to be done and this process requires thoroughness work since it is the main heart of the project in determining the amount of voltage generated.

Electrical part, in the other hands, is an additional part in this project to enhance the output of the generator to improve the performance and efficiency of the prototype. In this electrical part, the primary thing is booster circuit which used to step up the input voltage into higher value.

3.2 Key milestone

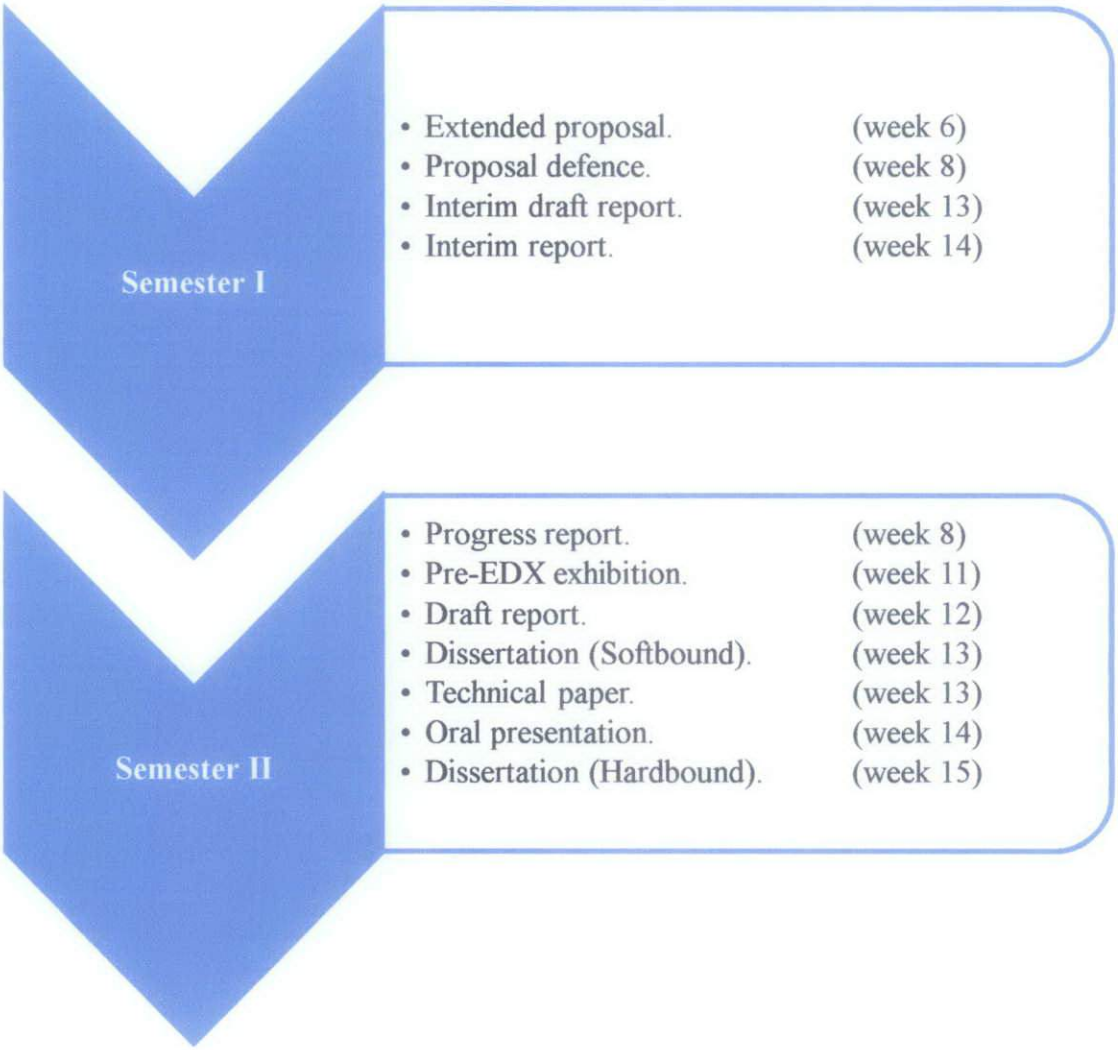

Figure 19: Key milestone for Semester I and Semester II.

3.3 Project Activities

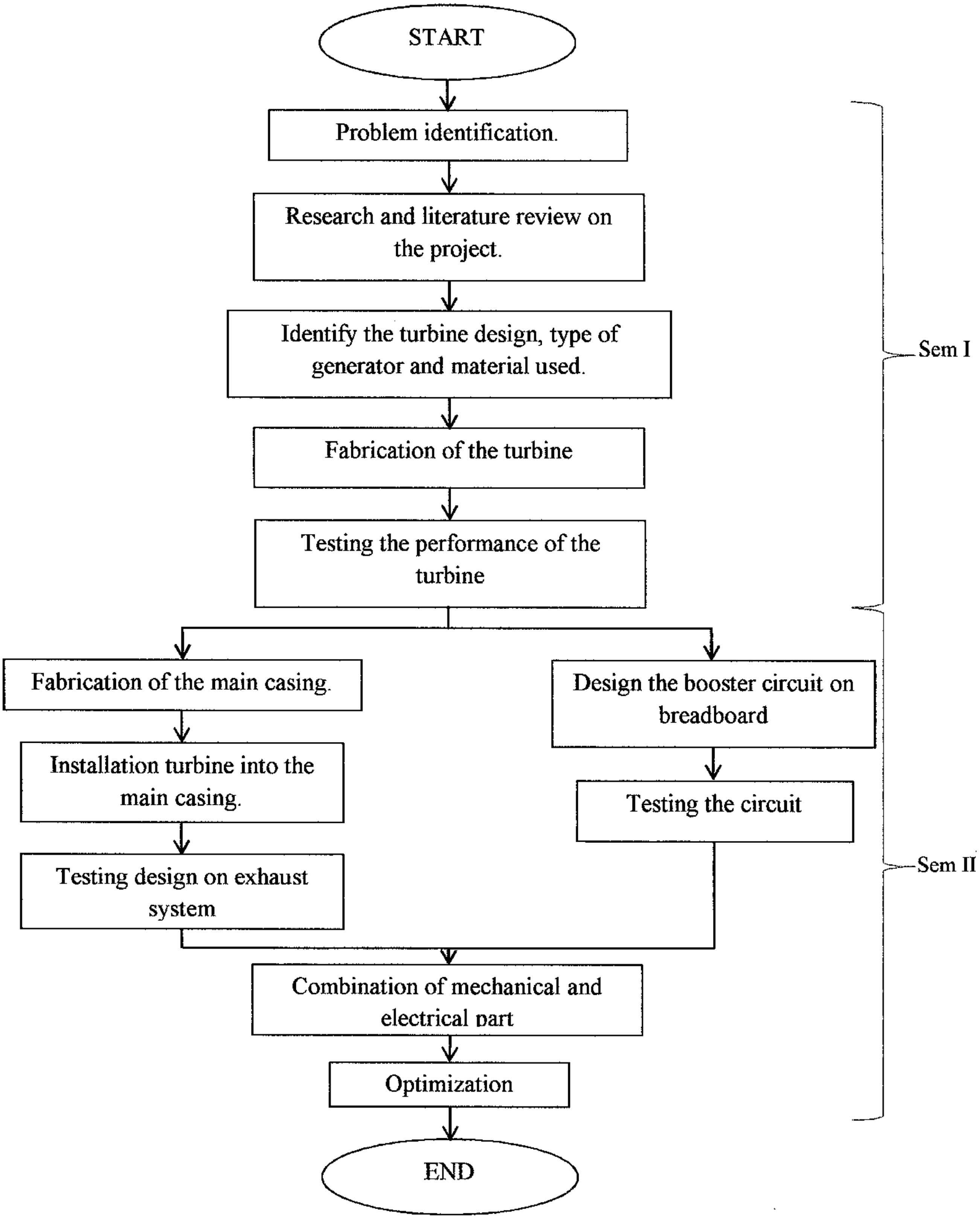

Figure 20: Flow chart of project in Semester I and Semester II

3.4 Tool and Equipment Used

Table 1 below shows the tools, equipment and materials used in this project.

Table 1: List of Tools, Equipment and Materials

Tools	**Equipments**	**Materials**
Soldering iron	Multimeter	Turbine
Long nose	Tachometer	DC generator
Allen key	Power supply	Bearing
Plier	Timer	-
Silicon glue	-	-
Wire cutter	-	-

3.5 Proposed PMDC motor as DC Generator

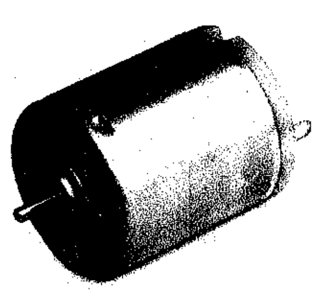

Figure 21: Permanent magnet DC motor.

Figure 21 above shows the PMDC motor that used in this project. This DC motor has a nominal voltage of 12V. The reason of choosing this motor is because the size of the motor itself is small in meet the specification of the project and also available in the market, means that easily to purchase. Not only that, the price of this motor is quite cheap and affordable.

3.5.1 Specification and Parameter of Proposed Motor

This specification of the motor is important in providing some information in the testing of the motor and prevents the motor from any damages. *Table 2* below shows the specification of the proposed motor.

Table 2: Specification of the proposed motor

Dimension	
Diameter	33mm
Length	27mm
Nominal Value	
Voltage (DC)	12V
No load:	
Current	0.05A
Speed	2,900rpm
At maximum efficiency:	
Current	0.11A
Speed	2,000rpm
Torque	2.8mNm
Output	0.58W
Effective	43.9%
At stall:	
Current	0.24A
Torque	8.8mNm
Direction of rotation	CW/CCW

3.6 Prototype Development

The foremost things that need to be done are to fabricate the turbine and the casing of the turbine. The turbine is the most critical part of the prototype since it will determine the whole performance of the prototype.

3.6.1 Prototype Design

Before proceed to the fabrication process, first thing that needed to do is to draw the design of the prototype model. By using the SolidWork2009 software, the drawing for each part of the design can be created. For the detail dimensions of each drawing, engineering drawings are attached in Appendix B.

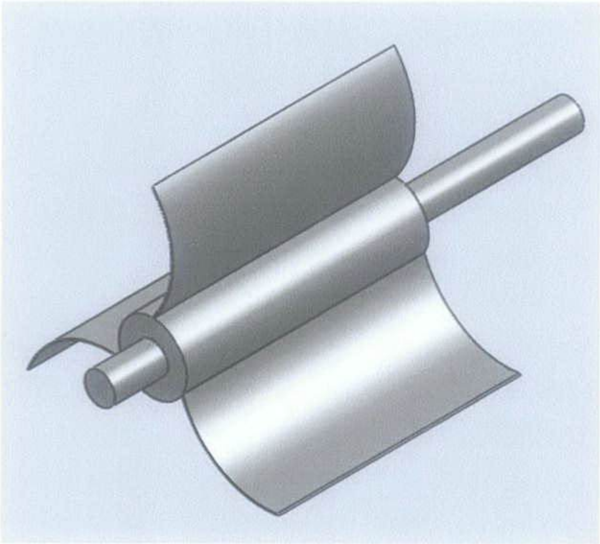

Figure 22: Three blades turbine.

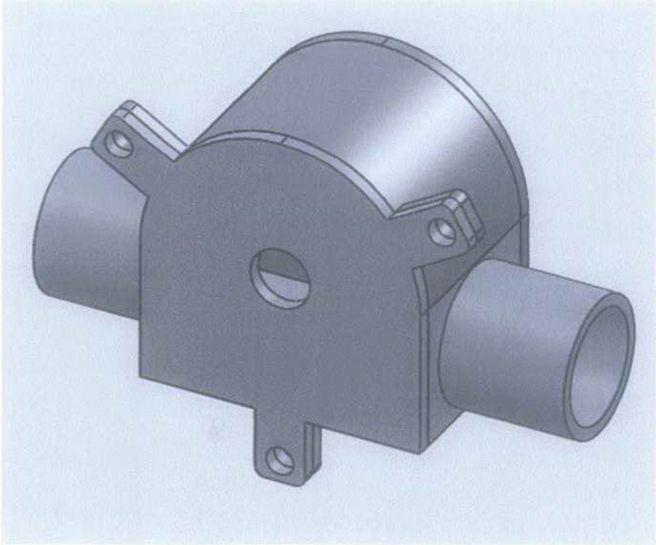

Figure 23: The main casing.

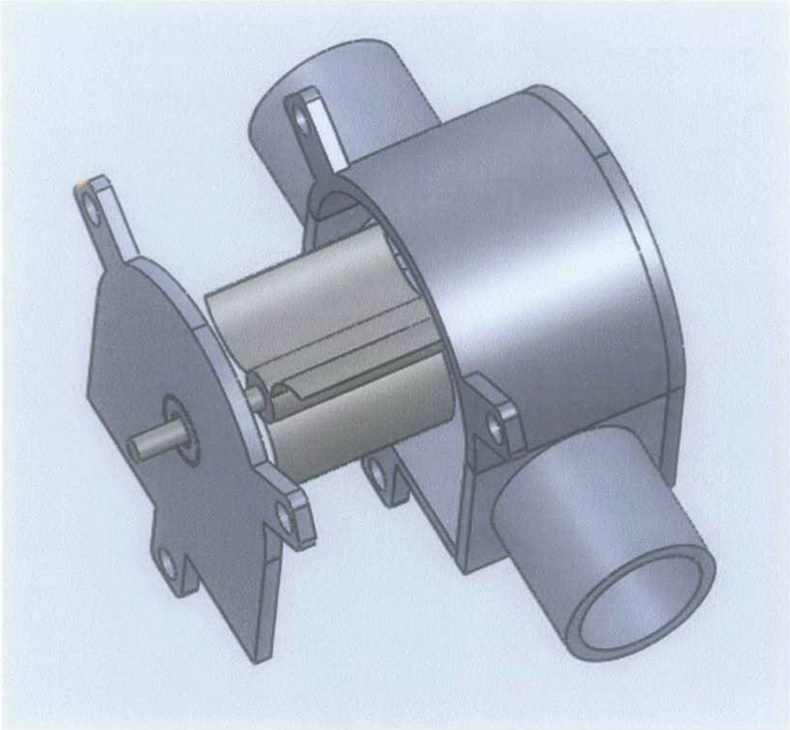

Figure 24: Exploded view of turbine with main casing.

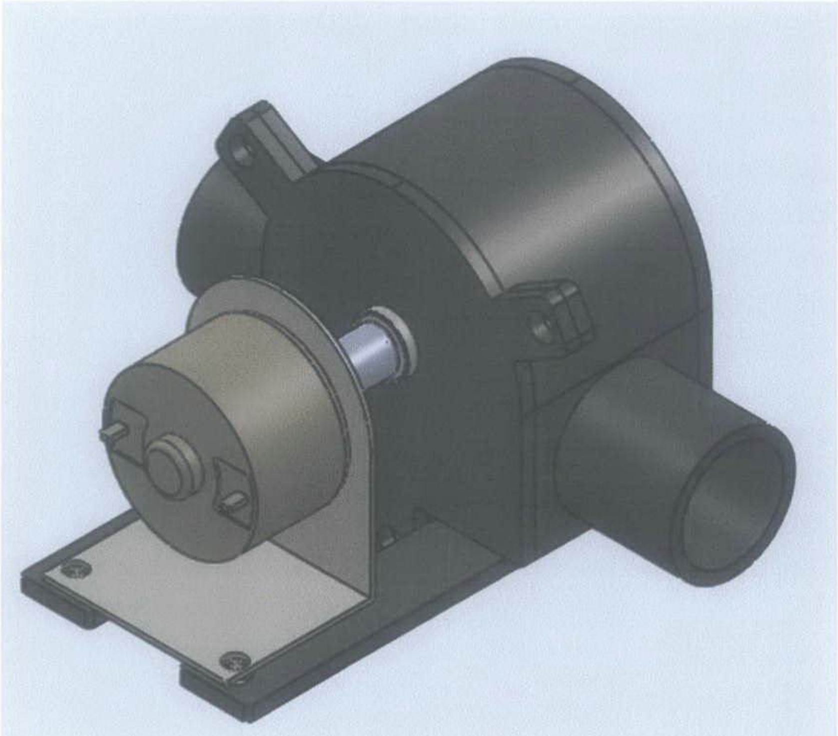

Figure 25: Isometric view of the complete design.

3.6.2 Fabrication Process

For the fabrication process, most of the work is done in laboratory. The fabrication processes are including fabricates the turbine and the casing of the prototype. The material used in the fabrication are mild steel and aluminium, thus the work involved are cutting, grinding, lathing, drilling and welding.

(a) Cutting

To cut the mild steel, the shearing machine is used. Since the aluminium is softer than mild steel, shearing machine is not needed to cut it, enough just used the shearing cutter.

(b) Grinding

Grinding is a process of to finish the last step to make the shape in high accuracy dimension and to show the high surface quality (low surface roughness). The machine used is a grinding machine. Mild steel plate is the mainly object used to be grind in order to form the shape of the dimension.

(c) Lathing

Lathe used in the fabrication process is to make the shaft of the turbine. Basically lathe is operations of cutting, sanding, knurling or deformation with tools that are applied to work piece to create an object which has symmetry about an axis of rotation.

(d) Drilling

One of the main processes to make hole on the mild steel and aluminum plate is drilling. Two types of drilling machine used during the fabrication process are pistol-grid (corded) drill and drill press (for more precise drilling).

(e) Welding

Welding is process of joining the mild steel plate by melting the work piece and adding the filler material to form a pool of molten material that cools to become a strong joint to produce the weld. After the welding process, the object then being grinds to make the surface less rough.

3.6.3 Turbine

The main material of the turbine is aluminium rod and aluminium sheet. The aluminium rod of diameter 19.5mm is used to make the shaft of the turbine. The rod then being lathe using the lathe machine to make the diameter of the rod smaller and according to the dimension needed. The aluminum sheet is used to make the blade of the turbine. The thickness of the aluminum sheet is 0.5mm.

The turbine has three blades that had been made it curve so that it can cope the air flow that through the turbine. Without having the curve, the speed of the turbine will be slow and affect overall turbine performance. The *Figure 26* below shows the turbine that already being fabricated.

Figure 26: Three blades turbine after fabrication.

At both of the turbine shaft, there is a bearing that used to ensure the rotation of the turbine is smooth and reduce the friction between the shaft and the casing. The bearing also uses to hold the turbine and make the turbine evenly located in the casing.

3.6.4 The Main Casing for the Turbine

For the casing, the main material is mild steel. Since the mild steel already available in the lab, so, this material is being used for constructing the casing. Compare to the aluminum, mild steel can be weld. The thickness of the mild steel plate is 2mm while the thickness of the mild steel rod is 3mm. The *Figure 27* below shows the casing of the turbine.

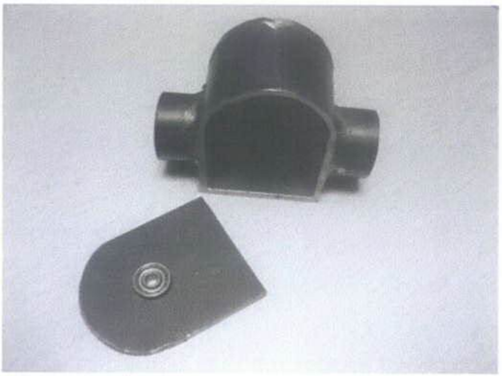

Figure 27: The main casing after fabrication.

Based on the *Figure 27*, one side of the casing is freely open. The reason for this is because to make the turbine easily taken in and out for maintenance purposes. Both mild steel rods are weld on the left and right of the main casing that later to be used to attach at the exhaust for air flow in and out.

As shown in the *Figure 28* below, that is the final picture of the finish fabrication process together with generator attach on it.

Figure 28: The complete model with DC generator attached.

3.7 Conclusion

The methodology in completing this project begins with research activities. In research activities, information related to the project is gathered to give guidance and ideas of what should be done. Most of these information are about technology of wind generator, turbine type and generator.

Key milestone being revised in order to keep track on several datelines on items needed to be submitted. Then, flow chart of project activities and Gantt chart are planned to ensure all works follow the schedule and complete the project on given period of time.

In prototype development, the turbine and casing were fabricated in mechanical laboratory. Using appropriate tools and machines, the fabrication process went smooth and the turbine and casing were successfully produced.

CHAPTER 4

RESULTS AND DISCUSSIONS

Results and discussion is a chapter that shows the output of the prototype after several tests done. The purpose of having these tests is to ensure the prototype will produce output which can generate voltage and current that meets the requirement of the project's objectives; to be able charge a 5V electrical application device such as hand phone.

4.1 Experimental Result

The experimental results are including the open circuit test, booster circuit test, complete circuit, system test, and overall system test.

4.1.1 Open Circuit Test

Apart from the fabrication process, an experimental process is also being done to test the DC motor in open circuit test. Open circuit test is done by using two motor that joining together with a coupler. One motor is act as the source to rotating the second motor. Thus, the second motor is act as a generator.

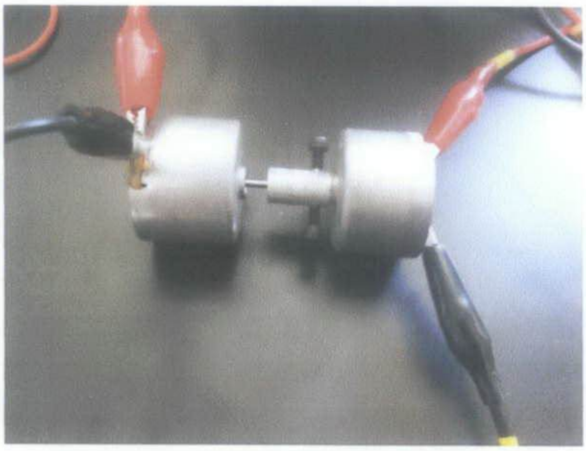

Figure 29: Setup for open circuit test.

By making this testing, the various speed of the motor will cause the variation of voltage and current produced by the generator. To make the motor speed varies, the applied voltage need to be varies also. The increment speed of motor is varying for every 100rpm then the voltage and current generated is captured at the generator (second motor).

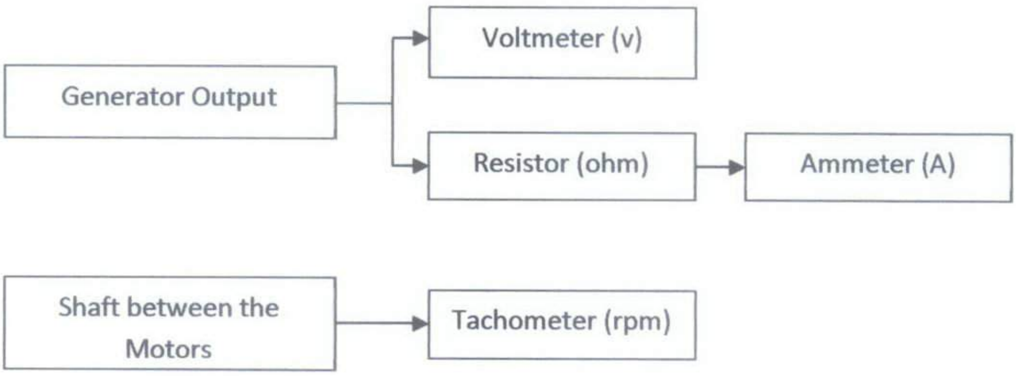

Figure 30: Equipment used in the open circuit test.

The speed of the motor is varied by changing the amount of voltage supply. To keep track on the speed of the shaft, a tachometer is used to measure the speed in rpm. In order to make the speed increases, the voltage applied also need to be increased. Theoretically, when the speed of the shaft rotation increases, the voltage and current produced by the generator also increases.

As the voltage supply to the motor increases gradually, the speed of the motor are recorded for every 100rpm different. By using multimeter, the voltage and current produce by the generator are recorded.

The *Figure 31* below shows the relationship between the speed of the motor and, the voltage and current produced. The minimum speed that makes the generator to be rotated is about 50rpm. Thus, in order to turn the generator shaft, the speed required is 50rpm.

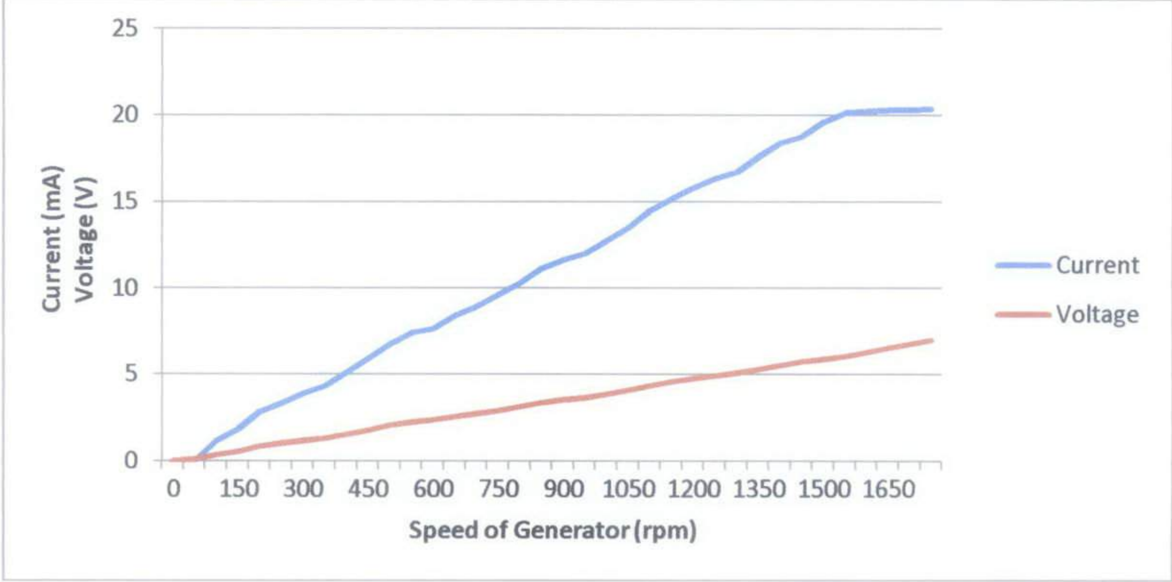

Figure 31: Voltage and Current Generated with Varying the Generator Speed.

4.1.2 Booster Circuit Test

In this testing, the main objective is to get the electrical component in the booster circuit working and able to charge the hand phone. The electrical component used in this testing are two rechargeable batteries, booster kit, voltage regulator and together with multimeter for voltage and current measurement.

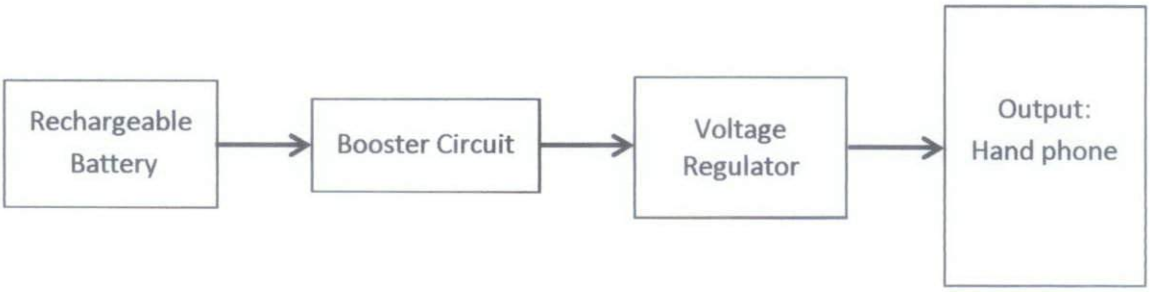

Figure 32: Connection for the circuit testing.

The power source is from the rechargeable battery. From that, the voltage will be boost to meet the requirement for charging the hand phone which is 5V. The voltage regulator is used to ensure the output from it will produce 5V and not exceed that value. The reason for using the voltage regulator is to prevent overvoltage to the hand phone that can damage the battery inside the hand phone.

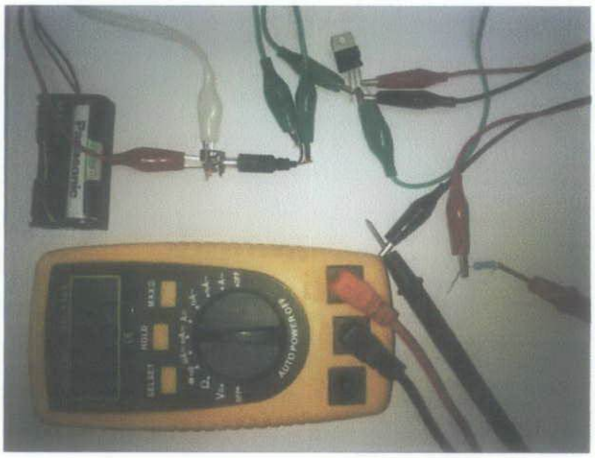

Figure 33: Setup connection together with digital multimeter.

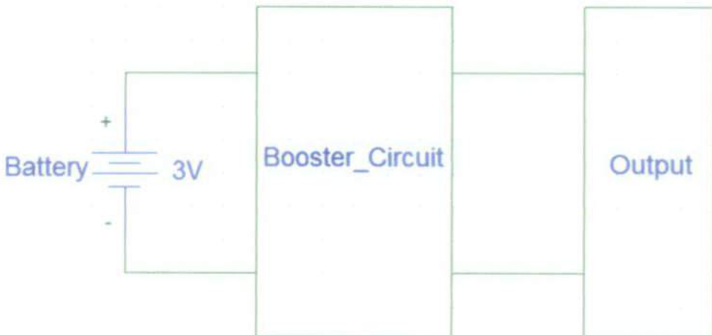

Figure 34: Schematic diagram for the booster circuit test.

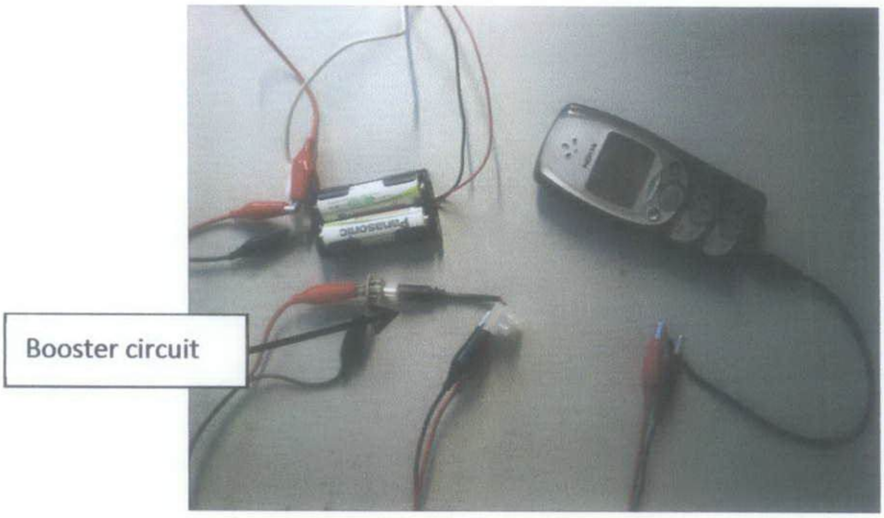

Figure 35: Hand phone charged using two batteries supply.

For the first test, one AA rechargeable battery supplied to the booster to see whether it can charge the hand phone. Then, two AA rechargeable batteries were used to supply the booster. The *Table 3* below shows the result of the finding.

Table 3: Result of booster circuit test

	Vin (V)	**Iin (mA)**	**Vout(V)**	**Iout(mA)**	**Charging condition**
One battery	1.5	1.21	3.65	0.12	Not charging
Two batteries	3.0	2.44	4.53	11.36	Charging

From the *Table 3* above, one battery as an input is not sufficient to charge the hand phone. Even the output voltage is meet the requirement, the current output of 0.12mA is not enough to supply energy for charging purposes. Thus, as two batteries supplies, the hand phone starts to charge. Output current of 11.36mA is adequate for the minimum value to make the hand phone charging.

4.1.3 Complete Electrical Circuit

In this section, the complete electrical circuit used in this project will be discussed. The mechanical part itself cannot produce enough output in order to charge the hand phone since the value of the voltage and current are too small. Thus, the conceptual idea of the electrical circuit to charge the hand phone can be seen on the *Figure 36* below.

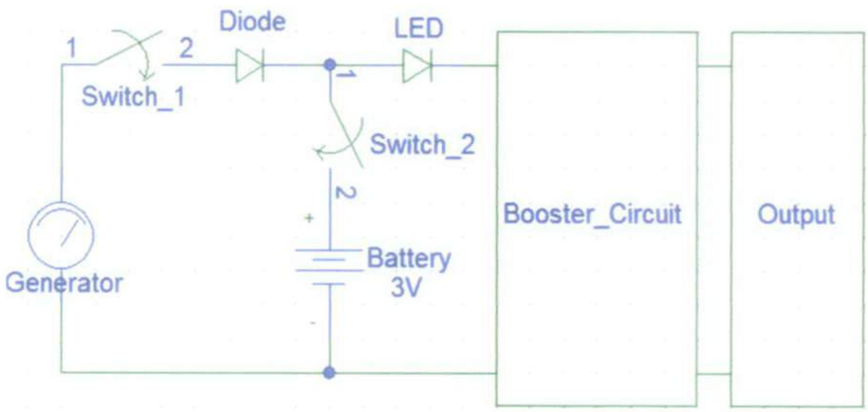

Figure 36: Schematic diagram for complete electrical circuit.

Based on the *Figure 36*, the generated energy from the generator will be supplied to the rechargeable batteries. The led indicates that there are voltage and current through the connection. The function of the diode is to ensure the flow of the current will be in one direction, which is only from the generator to the batteries.

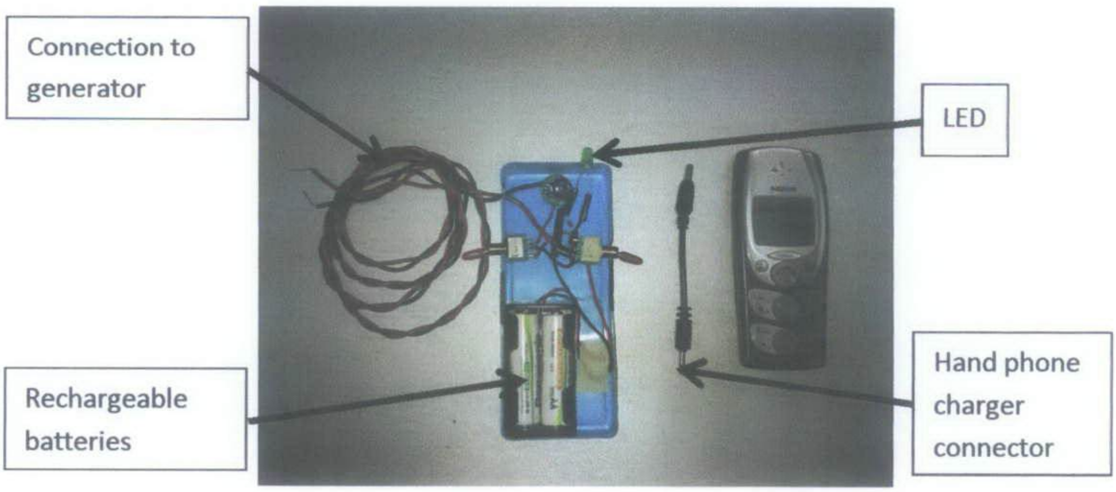

Figure 37: Electrical circuit with hand phone.

4.1.4 System Test

The system test is an experimental process to test the performance of the prototype that only involving the turbine and the DC generator. An air flow from the motorcycle exhaust will be supplied so that the turbine will be rotate and turn the rotor in the generator. After that, voltage and current generated will be recorded.

Figure 38: Voltage being measured from the generator output.

After the prototype done with the fabrication process, the turbine and the casing needed to be tested to see its performance. The testing process was being done by measuring the speed of the turbine with the load of the generator. The prototype model attached to the exhaust, it then being mounted to the motorcycle.

Figure 39: Prototype model attached to the exhaust.

As the motorcycle engine started, the air flow in the exhaust will be produced. Without press the throttle, the constant exhaust's air flow gives the minimum flow rate. Thus, it this condition, the minimum speed or rotation of the turbine can be produced. At this rate, the voltage and current produced by the generator are also the minimum values.

Then, the throttle was pressed to increase the air flow in the exhaust. Theoretically, the voltage and the current produced will be increased as the air flow increases which affecting the rotor rotation in the generator. Since the readings are varying throughout the test, only the minimum and maximum readings are recorded. The results and findings of this testing are shown in *Table 4*.

Table 4: Speed and generated voltage and current

Speed of generator (rpm)		**Generated voltage (V)**		**Generated current (mA)**	
Minimum	**Maximum**	**Minimum**	**Maximum**	**Minimum**	**Maximum**
210	1017	0.68	4.64	1.56	12.34

4.1.5 Overall System Test

In this testing, the mechanical part and electrical part are being combined together to get the final output of the project. The turbine, generator and the electrical circuit are connected.

Figure 40: Electrical circuit connected to the generator.

Figure 41: Prototype attached to the motorcycle.

Based on this testing, the result obtained from this testing is tabulated in *Table 5*.

Table 5: Average generated voltage and current

Average generated voltage	5.12V
Average generated current	14.13mA

4.2 System Efficiency

Throughout these tests, the system efficiency is measured to see how the good the performance of this project. From overall system test, the power generated is:

- Speed of turbine : 1396 rpm
- Generated voltage : 5.12V
- Generated current : 14.13mA
- Generated power : $P_{Generated} = VI$

$$= (5.12V)(14.13mA)$$

$$= 0.0723W$$

From the open circuit test, the power generated based on corresponding speed of 1396 rpm is:

- Speed of turbine : 1396rpm
- Average generated voltage : 5.54V
- Average generated current : 18.41mA
- Generated power : $P_{Max} = VI$

$$= (5.54V)(18.41mA)$$

$$= 0.1020W$$

Thus, the system efficiency is:

$$Efficiency\ (\%) = (P_{Generated} / P_{Max}) \times 100\%$$

$$= (0.0723/0.1020) \times 100\%$$

$$= 70.9\%$$

4.3 Conclusion

From the tests that already being conducted which consist of open circuit test, booster circuit test, system test and overall system test, the outcome results are meet the expectation of the project objective.

For open circuit test, the performance of the DC motor can be measured. The maximum voltage produce by the generator is about 7.01V of and current produce is around 20.36mA at speed of 1750rpm. These values are the maximum rating of this 12V DC motor. Booster circuit test is conducted to assure what is the minimum input voltage and current needed for the booster in order for the hand phone to be charged. Thus, results show that 3.0V and 2.44mA input are required for this operation.

The system test gives the output of minimum and maximum generated voltage and current when the prototype being attached to the motorcycle's exhaust without electrical circuit. The maximum voltage generated is 4.64 and current generated is 12.34mA. In overall system test, the complete prototype combining mechanical part and electrical part provides the final output of the project. As the voltage generated by generator and being boost by booster circuit, the average generated voltage is 5.12V and average generated current is 14.13mA.

These tests do give the performance of this prototype. The final outputs from the overall system test achieve objective function of this micro air flow generator which can charge a hand phone.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

For the conclusion, all the tasks that listed in the Gantt chart for whole semester, FYP I and FYP II are completed. The prototype of Micro Air Flow Generator has been built which consists of turbine and generator by using the concept of wind generator system. This prototype is being attached to the motorcycle exhaust to harness energy from the air flow to generate electricity for storage energy in the rechargeable battery and then being used to charge any 5V electric appliance such as hand phone.

From the literature review, technology on wind energy is generally used by generation from middle ages; used for milling cereal and grain for food production, pumping out water, and also generate electricity power. The wind turbine itself has two types, which are vertical-axis wind turbine and horizontal-axis wind turbine. After justification, vertical-axis wind turbine type is chosen for the project and Savinous turbine is selected among other types of VAWT.

There are two main parts that need to be considered in this project which are the critical point; the selection of suitable generator and the size of the turbine. Thus, a permanent magnet generator is chosen because of it fit the requirement and yet small in size. The turbine itself fabricated in small size so that it can be fit and appropriate to the dimension of the motorcycle exhaust.

As the fabrication process completed, several tests conducted which are open circuit test, booster circuit test and system test in order to see the output of the prototype. Throughout these tests, any flaw can be detected and lead to the optimization process to improve the project's performance.

From the generator, the power generated through the rechargeable battery and then the voltage being boost to higher value level. This boosts voltage then able to charge the hand phone and can be used anytime even in emergency cases. Therefore, the objectives of this project to develop micro air-flow generator at motorcycle exhaust and to produce a device that portable, environmental, and user friendly are achieved.

5.2 Recommendations

During the experimental process, the turbine was not rotating smoothly since the bearing that attached to both side of the shaft are not smooth enough and the orientation of the shaft is not totally accurate. This happen because there is an error made during the fabrication process. Thus, in order to increase the performance, the first thing that needed to do is to change the existed bearing with a new one that has smooth rotation.

For the future work, to refine the prototype, it needs to be very accurate of the shaft orientation so that the shaft can turn evenly with low friction caused by the bearing. As the friction reduced, the turbine can rotate faster and increase the performance of the generator. Furthermore, using a different type of materials for the casing such as aluminium plate will make the prototype less heavy and easy for fabrication process.

In addition, to get a better output power from the generator, a very good and efficient generator is a better choice. Not only that, a lower torque generator should be used in order to make the turbine easy to rotate and faster in rotation. The faster the rotation, the more voltage and current can be produced.

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APPENDIX A (Gantt chart)

No	Detail\Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Selection of project title															
2	Literature review on motor/generator															
3	Literature review on blade/turbine design															
4	Progress on Proposal work															
5	SolidWork/Catia Learning															
6	Submission of Extended Proposal Defence								M							
7	Identify the material used for prototype								I D							
8	Propose a design concept of the prototype								S E							
9	Design a blade and turbine system								M							
10	Progress on blade development															
11	Proposal Defence															
12	Progress on Interim work															
13	Submission of Interim Draft Report															
14	Submission of Interim Report															

Figure 42: Gantt chart for Semester I.

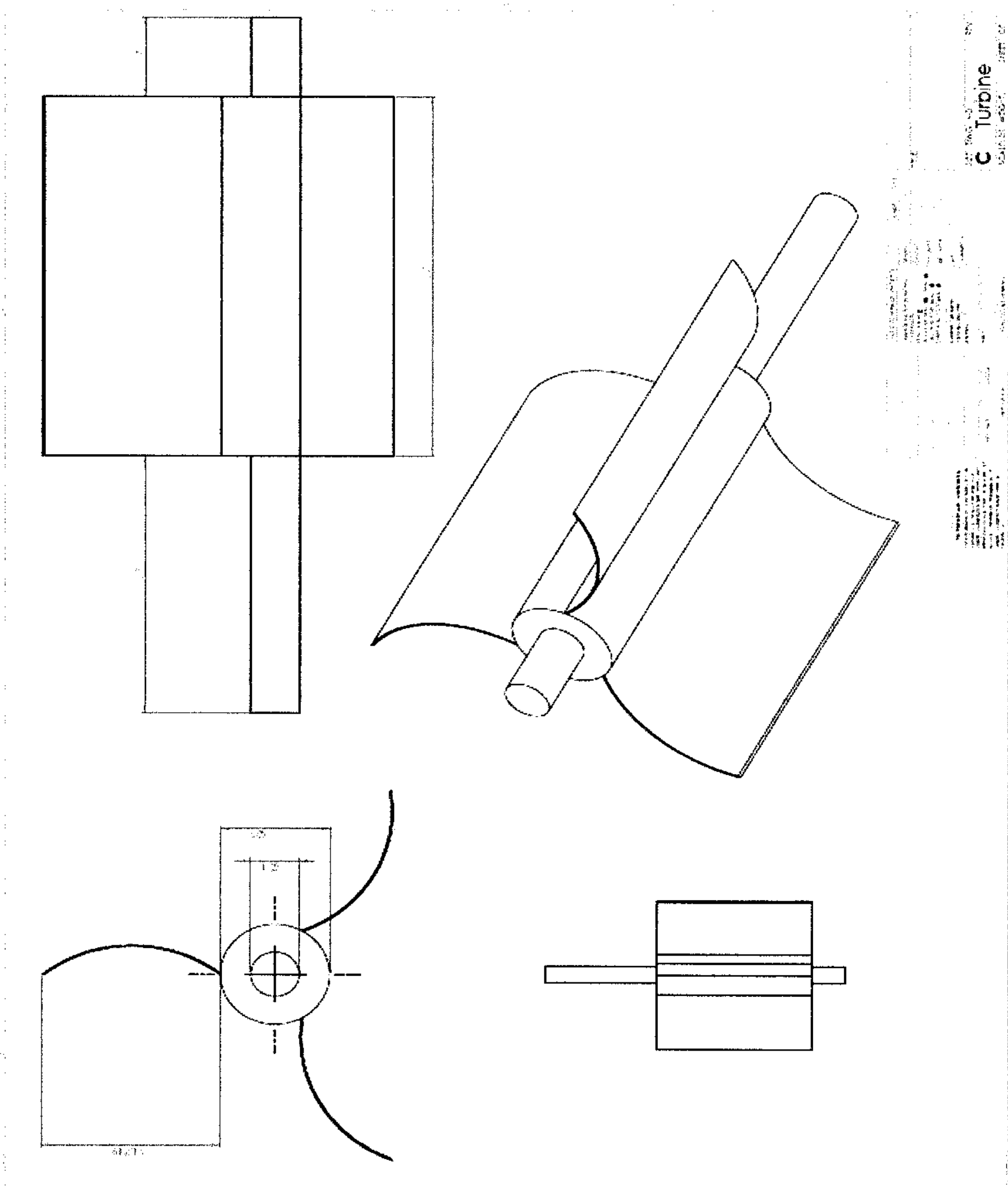
No	Detail\Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14	15
1	Fabricating the prototype design (casing)																
2	Construct the electrical circuit + generator																
3	Assembling the blade, generator and casing																
5	Experimenting/Testing the blade speed																
6	Testing on generator (electricity produce)																
7	Progress on Progress report								M								
8	Submission of Progress Report								I D								
9	Optimization of the design																
10	Finalize the design								S								
11	Pre-EDX								E								
12	Submission of Draft Report								M								
13	Submission of Dissertation (Soft Bound)																
14	Submission of Technical Paper																
15	Oral Presentation																
16	Submission of Project Dissertation(Hard Bound)																

Figure 43: Gantt chart for Semester II.

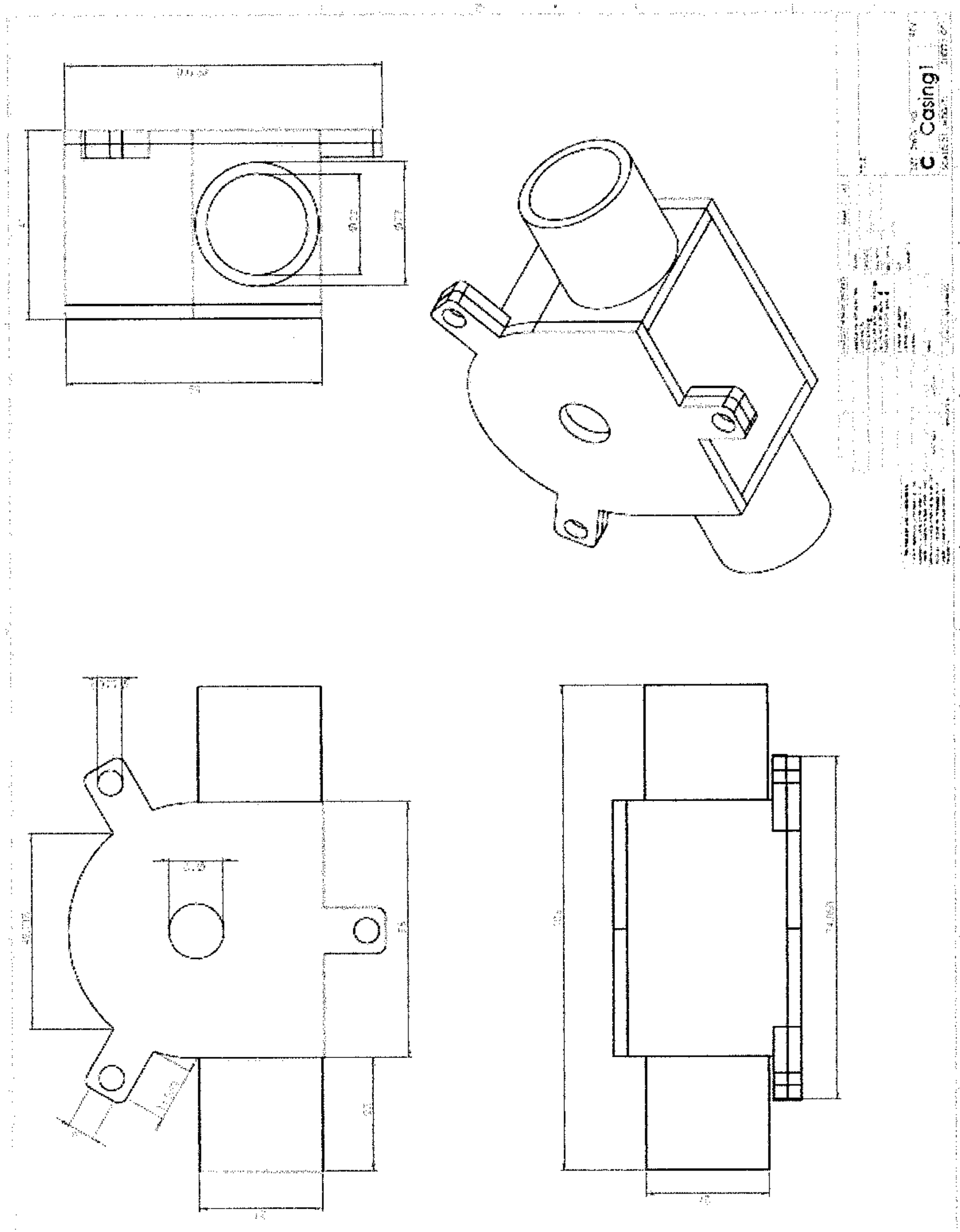
APPENDIX B

Engineering Drawing (all units in mm)

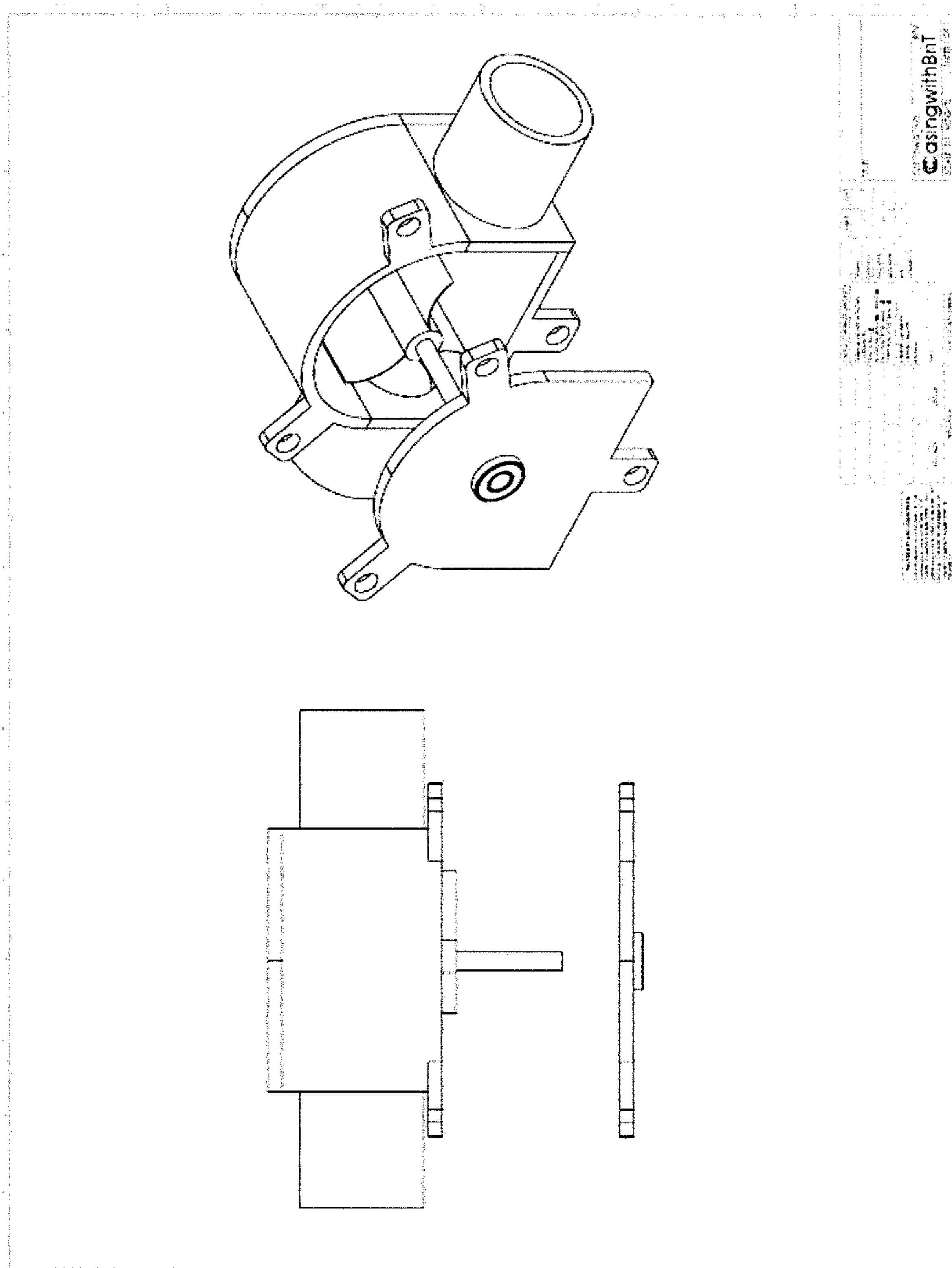
(a) Turbine



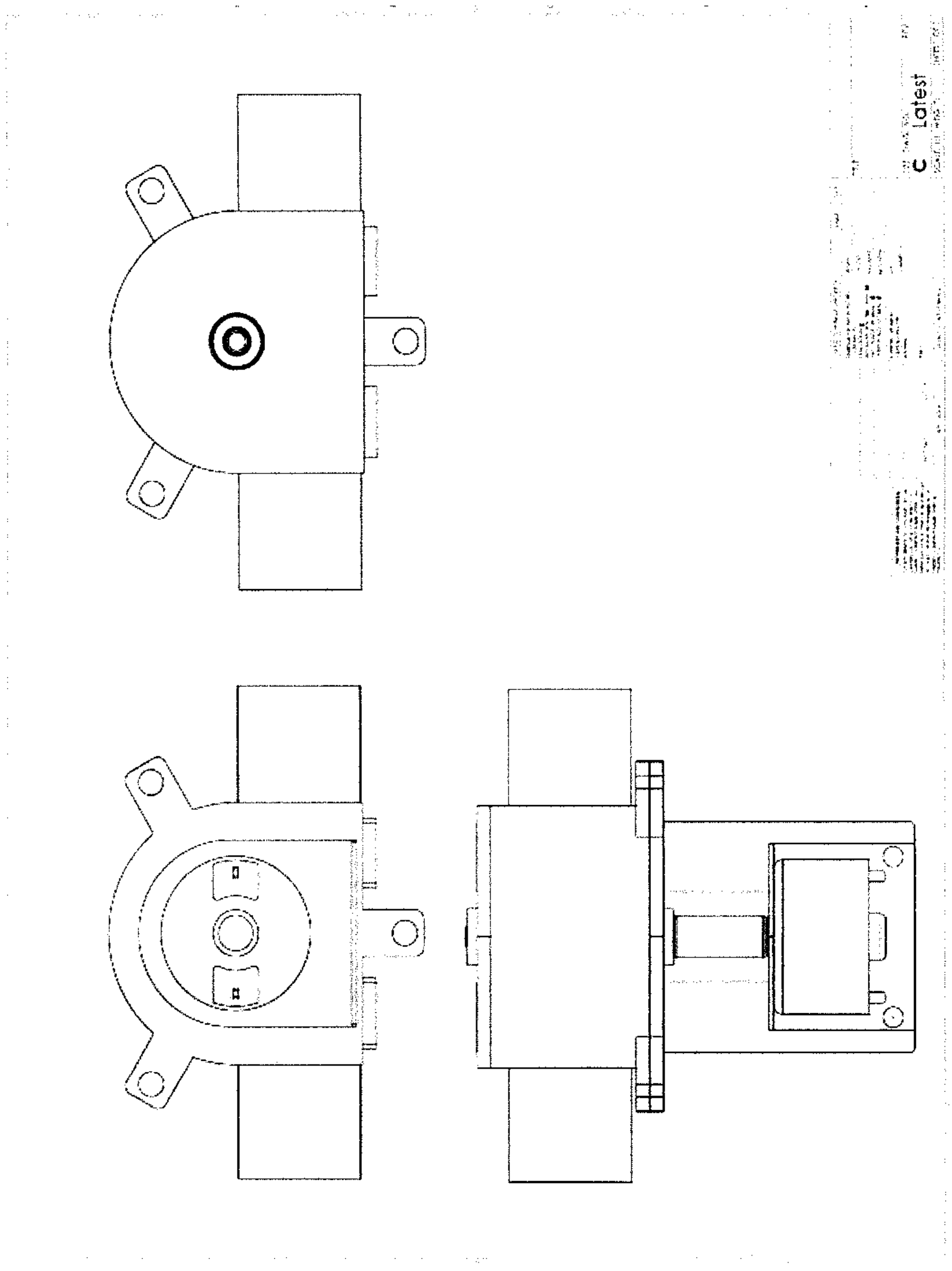
(b) Main casing

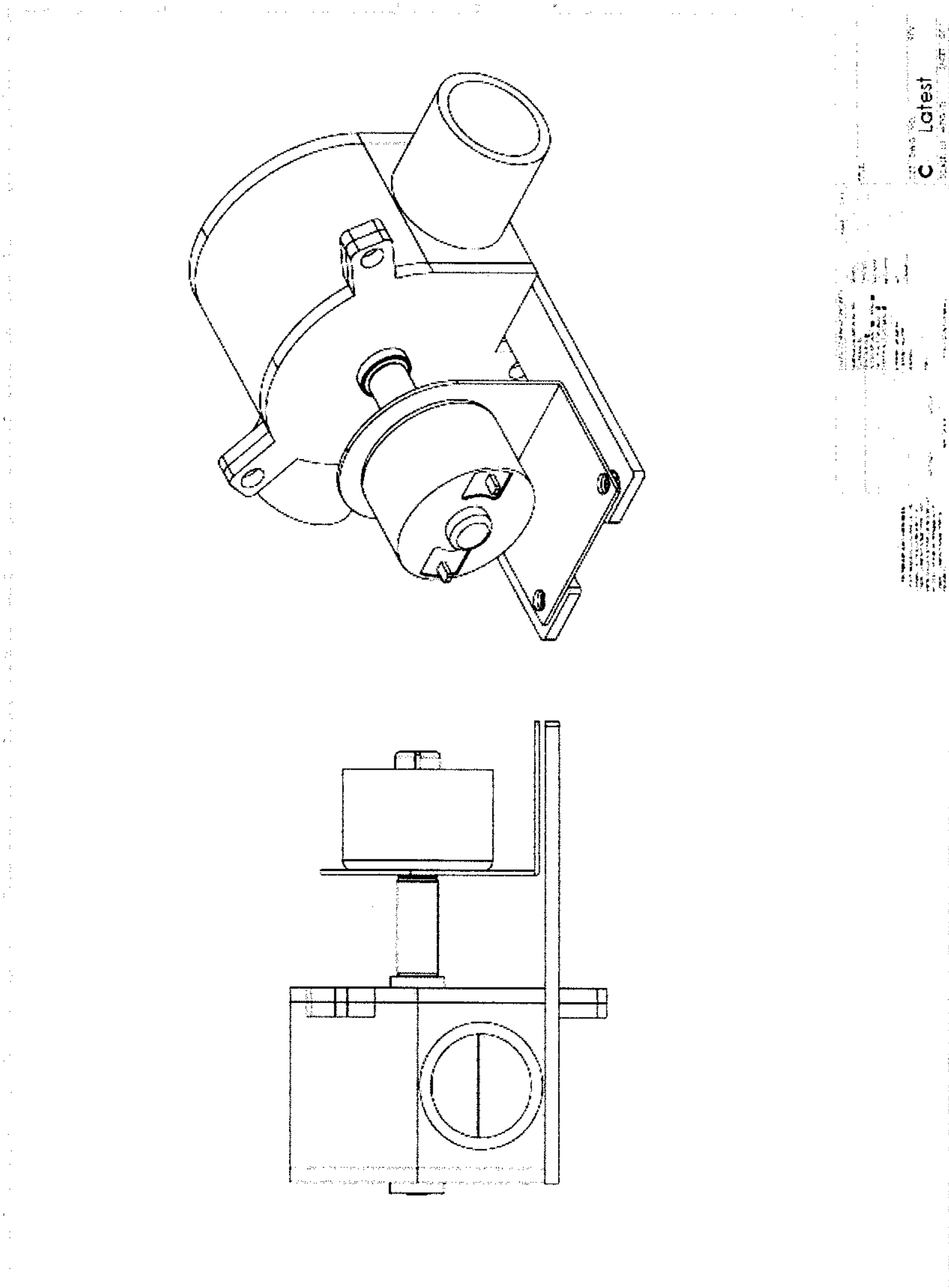


(c) Turbine with casing



(d) Overall design

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