MICRO HYDRO GENERATOR FOR HOME PIPELINE

By

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CERTIFICATION OF APPROVAL

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September 2011

CERTIFICATION 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 acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Mohd Amirullah Bin Yaacob

ABSTRACT

The total energy demand in Malaysia was 522, 199 GWh. The demand for electricity in Malaysia rises every year with an average of 2, 533 GWh per year. Malaysia receives an annual rainfall about 990 billion cubic meters of water over the country. Generally, there are about 16, 283 million litres of water being used every day. This project is about how to produce electricity by using a renewable energy, which is water. It can be utilized to produce electricity using the flow of water in home pipeline. The report presents a development of Micro Hydro Generator that will install in domestic pipeline. The flow of water in pipeline will force to rotate the turbine then will move the shaft of generator. Rotation of generator's shaft will induce a magnetic field and produce electricity. This electricity will be transferred into rechargeable battery for energy storage bank. This report is consisting of introduction, problem statement, literature review, methodology, results and discussion and conclusion. Introduction part will brief about the background study of the project, define the problem statement and the scope of works will be conducted during the project. The progress is followed by describe about general hydro generator system that had been used today. Literature review part will explain about various hydro generation technologies. The next step is proposing the methodology of the project, which is procedure on how to fabricate the overall prototype design. The proposed design will be selected based on literature review analysis. The data analysis will be conducted during experimental work to achieve an expected performance of micro hydro generator.

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CHAPTER 1

INTRODUCTION

1.1 Background Study

Malaysia lies entirely in the equatorial zone. The climate is governed by the yearly alternation of the northeast and southwest monsoons. The northeast monsoon occurs from November till March, and the southwest monsoon between May and September. The northeast monsoon brings heavy rains and extensive flooding to the east coast of Peninsular Malaysia, while the west coast receives relatively little rain during the southwest monsoon owing to the sheltering effect of the mountains in Sumatra.

Malaysia receives an annual rainfall about 990 billion cubic meters of water over the country, surface runoff water about 556 billion cubic meters; evapo-transpiration water about 360 billion cubic meters, groundwater recharge is about 64 billion cubic meters, surface artificial storage (dams) about 25 billion cubic meters and groundwater storage (aquifers) is about 5000 billion cubic meters [1]. Groundwater accounts for 90 percent of the freshwater resources. The renewable water resources are 630 billion cubic meters - the summation of surface runoff and groundwater recharge. This translates into an annual average water availability of about 28 400 cubic meters per capita. This large amount of water usage can be utilized to produce renewable energy [1].

Malaysia is rich in water resources, whose development has been the basis for the socio-economic development of the country over the past decades. Mainly, water in Malaysia is supplied to the domestic usage and industrial sectors. Water that supplied to the domestic would be used as drinking water, watering plants, bathing, cooking and sanitation. Domestic fresh water supply is an important aspect of public utility to all kind of activities in daily life. Generally, in domestic usage like household, running water is flowing for distribution through the pipeline. Water that is flowing in the pipeline can generate electricity by using same mechanism used in dam power generation.

The objective of this project is to develop micro hydro generator for home pipeline. Some modification of the household pipeline will be made in order to produce electricity by using a mechanical to electrical power conversion. Turbine will be installed in the pipeline and connected to mini generator to produce electricity. Rotation of turbine will rotate the magnet that placed in the generator. High rotation of the magnet past copper coil in generator will produce a current and voltage. Voltage produced will be transfer and store in a battery charger.

A turbine blade plays an important role in order to optimize the performance of this micro hydro generator. Most of the turbines in the market are in big size that is not suitable to install in the household pipeline. Instead of get a product in the market, a small turbine blade is designed in order to meet the project requirement. The design of this turbine will determine how performance of the micro hydro generator.

1.2 Problem Statement

The generation of electricity plays an important role in order to meet energy demand in this country. Water pipeline of household is not fully utilized. The problem of this project is on how to produce electricity by using a renewable energy, which is water, as an alternative energy. According to these statements, the idea of micro hydro generator is come out. The water flowing in the pipeline can be used to generate electricity. This generator is applied to the flowing of water in the residential pipeline. Electricity is generated by converting kinetic energy into electrical energy. [2]

1.3 Objective

The main objective of this project is to develop a micro hydro generator for household pipeline. However, the other objectives are:

1. To conduct literature review on hydro technology.
2. To design and develop micro hydro generator system which include turbine, generator and circuit.
3. To test and analyze the performance of generator system using water pipeline.

1.4 Scope of Study

Chapter 1: This chapter covers introduction parts which include water background in Malaysia and the important of renewable energy.

Chapter 2: This chapter covers a literature review, which describe about various technology of hydro generation and the propose design of micro hydro generator.

Chapter 3: Chapter 3 covers methodology parts on how to fabricate a micro hydro generator for household pipeline.

Chapter 4: The experimental works will be described in this chapter. It covers a test and data analysis of the micro hydro generator to determine the performance.

Chapter 5: This chapter covers conclusions and recommendations of the project.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Micro hydro generator is basically based on the concept use in dam system. Generally, there is various technology of hydro generation system that had been used today. During conducting this project, some study and research had been carried out in other to explore about hydro generation technology.

2.2 Hydropower Technology

Hydropower is energy that comes from the force of moving water, which may be harnessed for useful purposes. Hydropower is called a renewable energy source because the water on the earth is continuously replenished by precipitation. As long as the water cycle continues, this energy won't run out. Hydropower has actually been around for centuries. In India, as well as Rome, mills were powered by water wheels for the production of everything from grain to timber. With the power of the water, usually a river, moving by the mill, the wheel outside the mill would be pushed, helping to create energy through pulleys and levers within the mill [3].

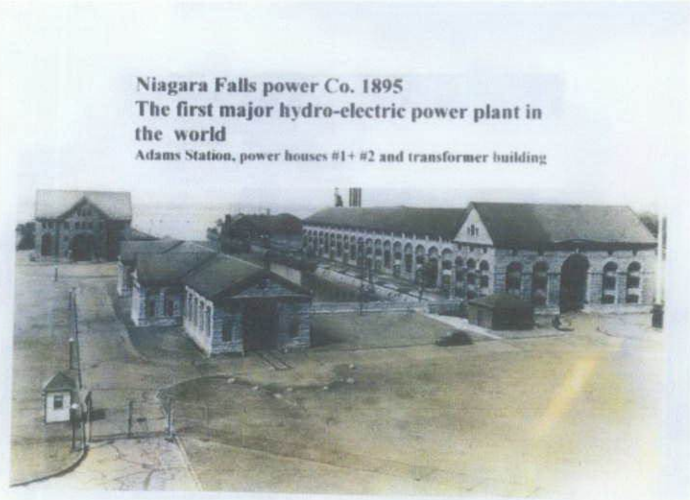

Figure 1 Niagara Hydropower Plant [4]

In the later 19th century, the force of falling water used to generate electricity. The first hydroelectric power plant was built at Niagara Falls in 1879 [4]. Nikola Tesla and George Westinghouse built the first hydro-electric power plant in Niagara Falls and started the electrification of the world. Adam's Power Station show in figure 1, the only remains of the old Niagara Falls Power Plant, may become a science museum. This museum would be devoted to Niagara Falls Power Plant; the first hydro-electric power plant in the world, this location is a great turning stone in the history of electricity. In the following decades, many more hydroelectric plants were built. As its height in the early 1940s, hydropower provided 33% of country's electricity. These days, hydropower is used for much more than just power mills. In the 21st century, it is powering the homes of millions of people and helping our civilization move from one that used dirty coal and oil, to one that uses the clean and renewable energy that is all around us.

The most common method of generating hydroelectric power is by damming rivers to store water in reservoirs [5]. Upon its release, the flow turns turbines, which then generate electricity as shows in Figure 2.The electricity is then transported via huge transmission lines to a local utility company.

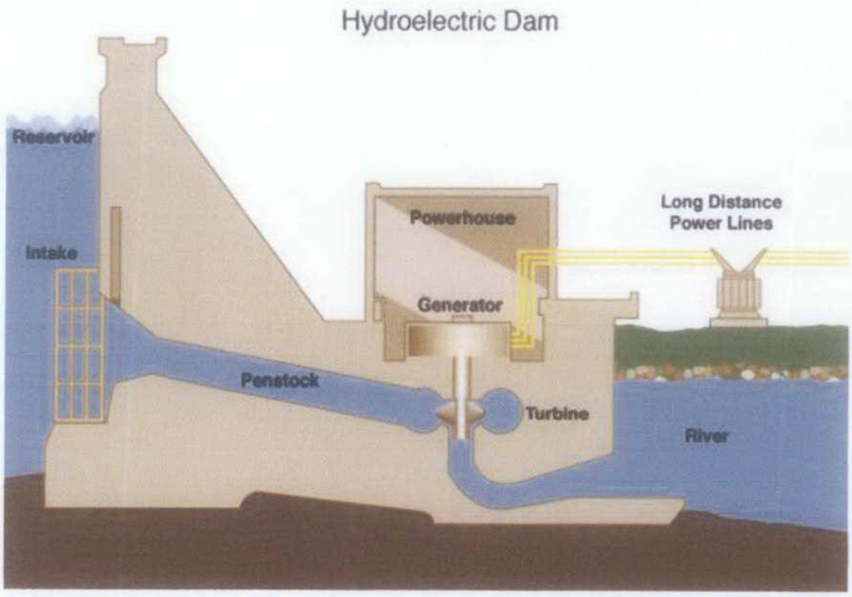

Figure 2 Hydroelectric Dam [6]

Hydropower does not necessarily require a dam, however. Small hydropower often simply uses canals or streams to produce enough electricity to light and run the appliances of individual households, for example.

There are several types of hydroelectric facilities; they are all powered by the kinetic energy of flowing water as it moves downstream. Generally, there are three major types of hydropower facilities, which are:

1. Impoundment
2. Diversion
3. Pumped Storage

2.2.1 Impoundment

Most common hydropower system type that had been applied is impoundment design where use one flow to generate electricity. An impoundment facility, it uses a dam to store water in a reservoir. Water released and will flows entered a turbine, rotate the turbine, then will rotate a generator's shaft to produce electricity. [7].

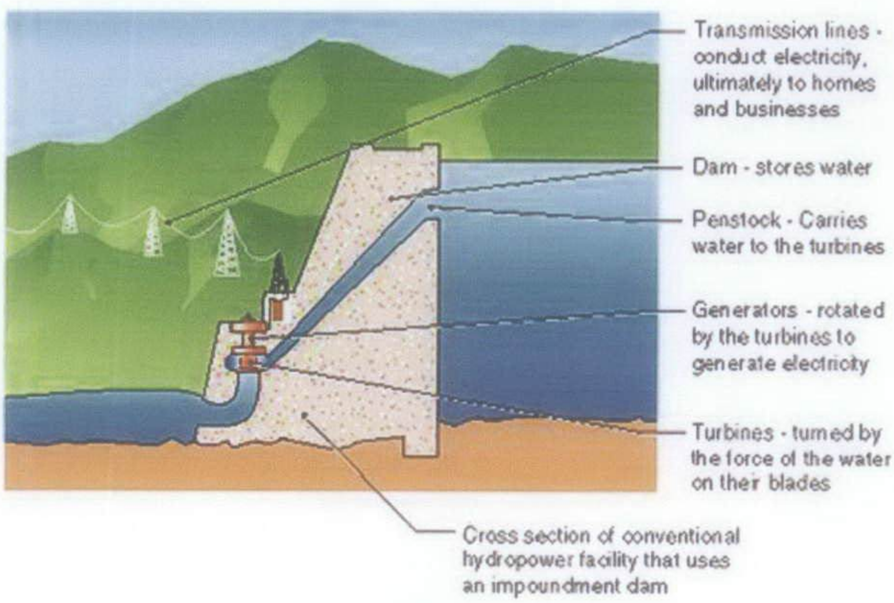

Figure 3 Impoundment Dam [8]

2.2.2 Diversion

A diversion, sometimes called run-of-river, facility channels a portion of a river through a canal or penstock. It may not require the use of a dam. It classified as a type of hydro generation use the natural downward flow of rivers and micro turbine generator to capture the kinetic force of the moving river. Portions of water from fast-flowing rivers, often at or near waterfalls, can be diverted through a penstock to a turbine set in the river or off to the side. The intake is typically the highest point of your hydro system, where water is diverted from the stream into the pipeline that feeds the turbine. This approach is inexpensive and easy to implement, it doesn't produce much power.

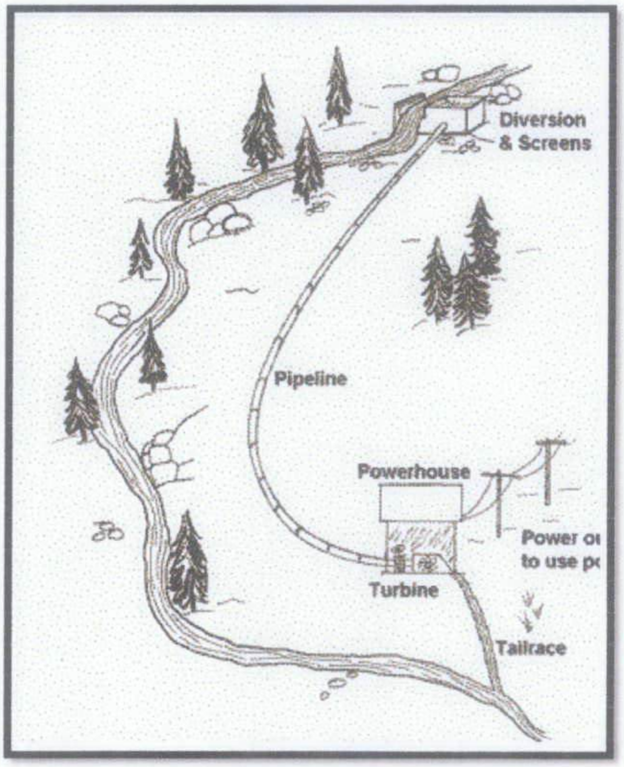

Figure 4 Diversion Systems [9]

2.2.3 Pumped Storage

The third type of hydropower system is pumped storage. The water will flow from the turbine into a lower reservoir which situated below the dam after the water produces electricity. When the demand for electricity is low, pumped storage facility stores energy by pumping water from a lower reservoir to an upper reservoir. During periods of high electrical demand, the water is released back to the lower reservoir to generate electricity.

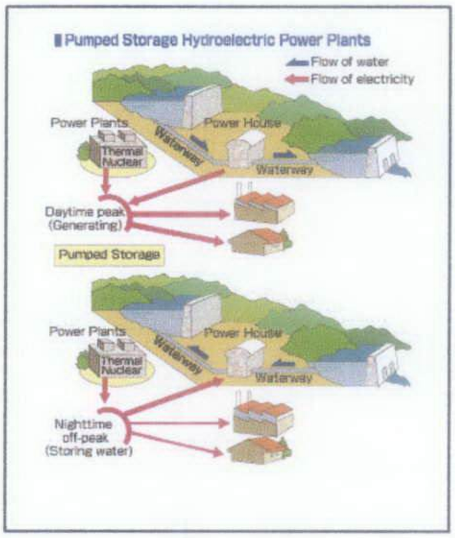

Figure 5 Pumped Storage Systems [9]

2.3 Basic Micro Hydro Generator System

Micro hydro generator usually used by homeowners, small business owners and farmers. It can generate at range 5 to 100 kilowatt (kW). Micro hydro generator is clean and cheap electricity for local applications. Basic micro hydro generator system is consisting of:

1. DC generator
2. Turbine
3. Circuit
4. Load

2.3.1 DC Generator

A generator is a machine that converts mechanical energy into electrical energy by using the principle of magnetic induction [10].

In this project design, permanent magnet motor is chosen as the DC generator due to its suitability to the project. Micro hydro generator will be installed at domestic pipeline, hence, a smaller size and lighter motor is perfectly suit for this project. For permanent magnet (PM) motor, a single conductor, shaped in the form of a loop, is positioned between the magnetic poles. As long as the loop is stationary, the magnetic field has no effect (no relative motion). When loop rotation happened, the loops will cuts through the magnetic field, and an electromagnetic field, EMF (voltage) is induced into the loop. EMF is induced into the conductor when there have a relative motion between a magnetic field and a conductor in that magnetic field. The magnitude of the induced EMF depends on the field strength and the rate at which the flux lines are cut.

Figure 6 DC Motor

2.3.2 Turbine

Water turbines were developed in the nineteenth century and were widely used for industrial power prior to electrical grids [12]. Turbine is mostly used for electric power generation. Water turbine is one of the main parts of Micro Hydro Generator. Flowing water is directed on to the blades of a turbine runner, creating a force on the blades. Since the runner is spinning, the force acts through a distance. In this way, energy is transferred from the water flow to the turbine. Turbine is fixed on a shaft, and the rotational motion of the turbine is transmitted by the shaft to a generator.

Choosing the best turbine blade design is very important in fabricate the micro hydro generator. The turbine must be moved by electrical motor and no hydraulic regulation is required. So, no oil leakage into the drinking water is possible. Water turbines are often classified as being impulse turbines or reaction turbine. In a reaction turbine the runners are fully immersed in water and are enclosed in a pressure casing [13]. The runner blade are angled so that pressure difference across them create lift forces, like those on aircraft wings, and the lift forces cause the runner to rotate. In an impulse turbine the runner operates in air, and is turned by one or multiple jets of water which make contact with the blade. There are many kinds of water turbine designs. Typical micro hydro generators have outputs of 10 kilowatts (kW) or less and can generate either DC or AC current depending upon the design [14].

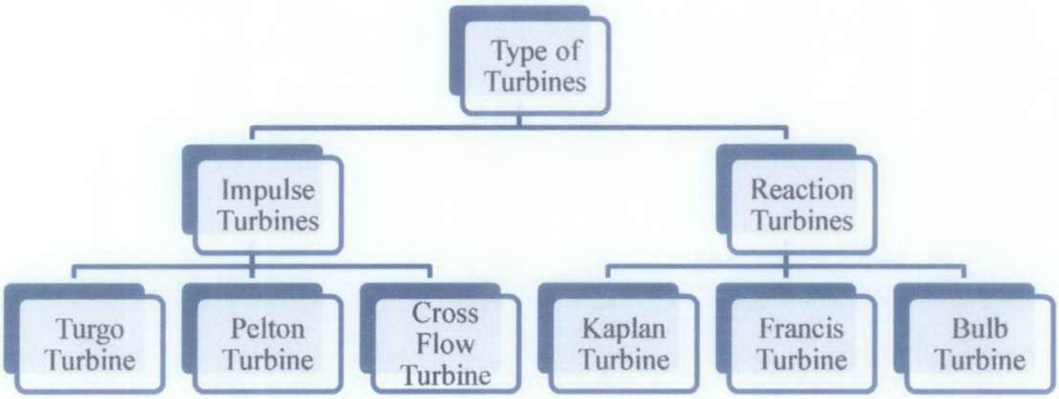

Figure 7 Types of Turbines

2.4 Performance of Micro Hydro Generator

Generally, the distance the water falls depends on the steepness of the terrain the water is moving across, or the height of a dam the water is stored behind. The farther the water falls, the more power it has. In fact, the power of falling water is 'directly proportional' to the distance it falls. In other words, water falling twice as far has twice much energy. It is important to note head is talking about the vertical distance the water falls – the distance the water travels horizontally is consequential only in expense of the system and friction losses. Head is usually measured in 'feet' [15].

More water falling through the turbine will produce more power. The amount of water available depends on the volume of water at the source. Power is also 'directly proportional' to river flow, or flow volume. A river with twice the amount of flowing water as another river can produce twice as much energy. Flow volume is usually measured in 'gallons per minute', or 'GPM'.

Impulse turbines are the most efficient choice for high head and low flow volume. The power produced by an impulse turbine comes entirely from the momentum of the water hitting the turbine runners. The water creates a direct push or impulse on the blades, and thus such turbines are called impulse turbines.

A reaction turbine is the best choice for low head and high flow volume. The reaction turbine, as the name implies, is turned reactive force rather than a direct push or impulse. The turbine blades turn in reaction to the pressure of the water falling on them. Reaction turbines can operate on heads as low as 2 feet, but require much higher flow rates than impulse turbines.

2.5 Conclusion

As a conclusion from this chapter, the design of micro hydro generator is proposed. A proposed design of the prototype is based on diversion system, which is use the natural downward flow of water and micro turbine generator to capture the kinetic force of the moving water. A diversion system is suitable to be applied in micro hydro generator for household pipeline that has a downward flow of water from tank to piping distribution.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter describes a methodology of the project, which shows the step on how to design and fabricate the overall design of micro hydro generator. Research and study about a project is done at early stage of the project. Mechanical part is referred to the prototype design which consists of generator, turbine blade and design of turbine housing. This part will be complete during Final Year Project 1 (FYP1). For the electrical part, it referred to process optimization of the prototype design, which add the function and improve the design performance, will be executed during Final Year Project 2 (FYP2).

3.2 Project Activities

FYP1 (Semester 1)

- **Documentation**
  - Perform research and study
  - Literature review
  - Prepare extended proposal
- **Practical Work**
  - Complete the design of turbine
  - Turbine's housing
  - Testing the turbine

FYP2 (Semester 2)

- **Documentation**
  - Progress report and technical report
  - Final report
- **Practical work**
  - Combination mechanical part (turbine) with an electrical part (generator/circuit)
  - Testing the prototype – power produce, efficiency, performa nce.

Figure 8 Tasks of the Project

3.3 Project Flowchart

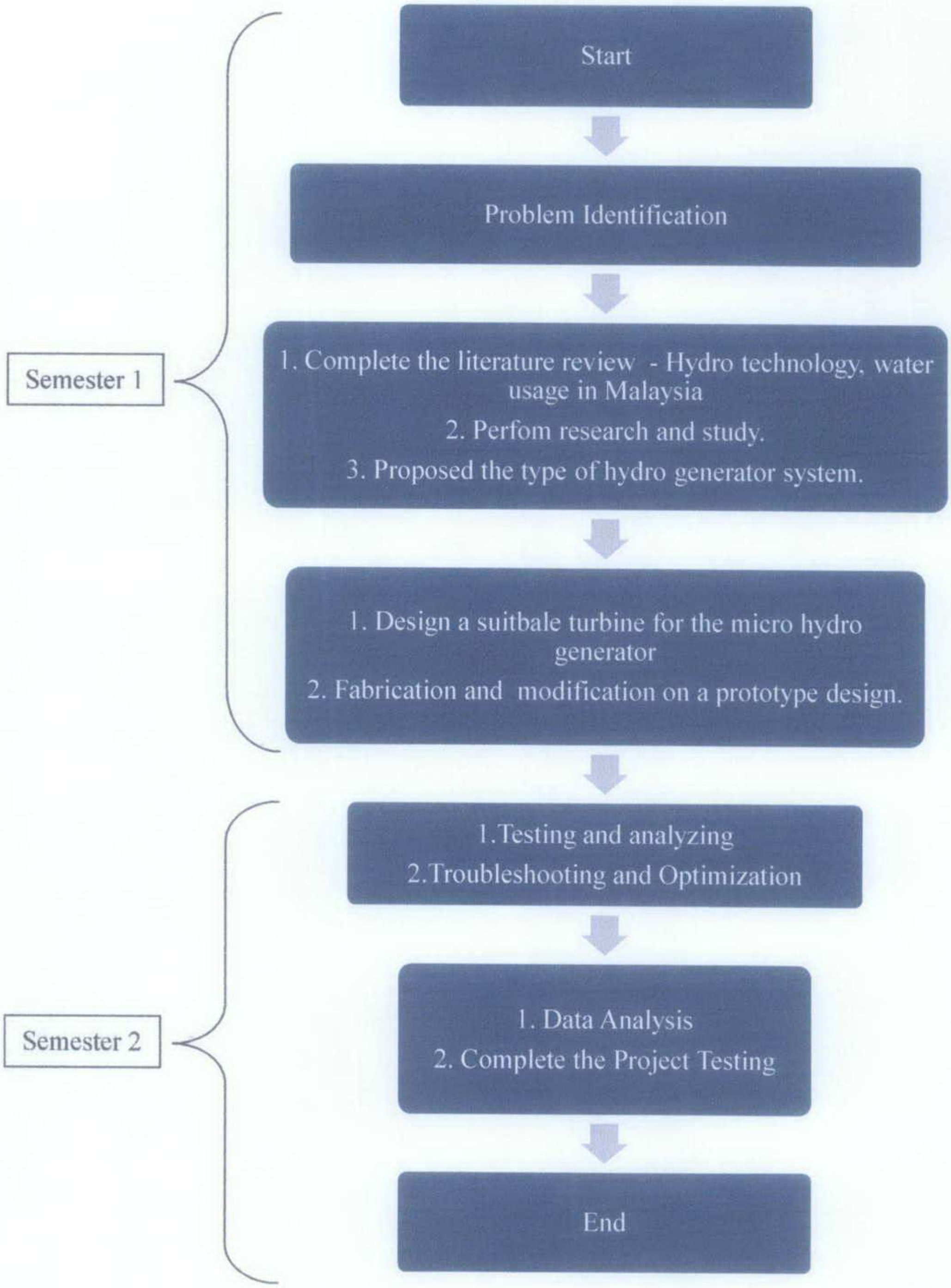

Figure 9 Project Flowchart

3.4 Tools and Equipments

Table 1 Tools and Equipments

Material	Tool	Equipment
Turbine Blade	Silicon Glue	Multi-meter
DC Generator	Pliers	Power Supply
PVC Pipe	Cutter	Mechanical Machine
Perspex	Chloroform	
Bearing & O-ring		
Shaft (Aluminum Rod)		

3.5 Prototype Design

In a prototype construction design, there are three (3) main parts that must be done for complete design of the Micro Hydro Generator; turbine design, turbine's casing and circuitry part. However, at this point of this, only two parts will be completed during FYP1, which are proposing the design of turbine and construct a casing of the turbine. While, the circuitry part including an installation of generator will be done during FYP2. The performance of prototype are mainly depends on the turbine and generator used in the project. The specifications for this prototype are discussed in the following parts.

3.5.1 Proposed Design

For this project, the prototype is consisting of:

1) Turbine and casing
2) Generator
3) Electrical part

A design of small turbine will be installed into its casing and connected to DC generator. Water will flow through the casing and start rotating the turbine. A turbine shaft will rotate the magnet that placed in the generator. High rotation of the magnet past copper coil in generator will produce a current and voltage. Voltage produced will be transfer and store in a battery charger and will be used as an alternative power supply.

3.5.2 Design of Turbine

Water turbine for this project is designed instead of selecting a complete turbine sold in the market. Typically, most of the turbines sold in the market are designed in bigger sizes, used for high power generation. All these turbines are not suitable for the prototype which to be installed in domestic pipeline. Referring to the design in the market, here comes some idea of designing own new turbine which specialist applied to Micro Hydro Generator. The design of the turbine is shown in Figure 10 and Figure 11.

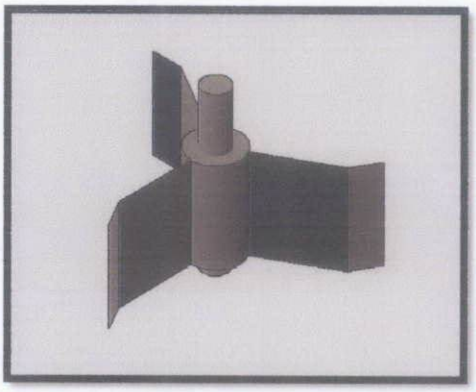

Figure 10 AutoCAD Turbine Design

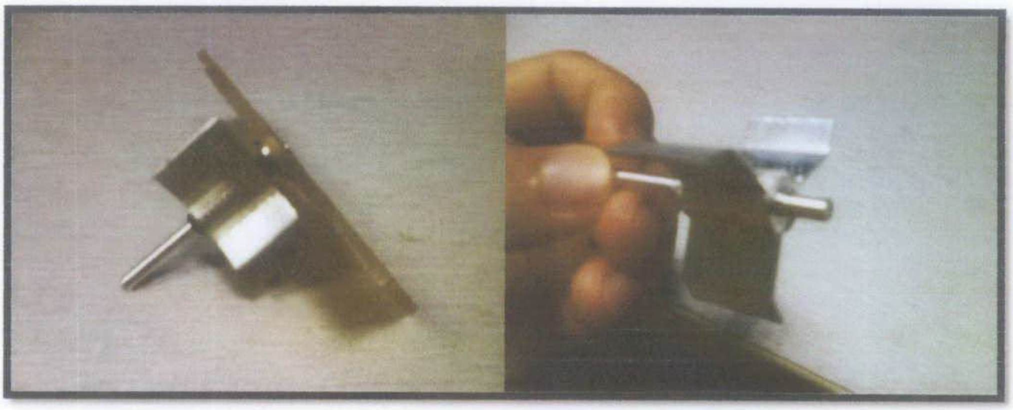

Figure 11 Design of Turbine

The turbine design is consist of blade, shaft, o-ring and bearing. The turbine had been made angle at end of blade in order to catch more water flow that attach on the blade's surface. This is because the water flow will push the turbine blade easily, then it will increase the torque to rotate the turbine. Refer to the picture above, it can be seen that o-ring is attached at the both side of the blade. The usage of o-ring is very important in order to avoid water leakage. The o-ring is functioning to avoid the water flowing inside turbine's casing from leakage through shaft's hole at the casing. Based on application of water pressure, where as the turbine is rotating, the pressure from the water will push the o-ring to the surface of the casing therefore it will block the water from flowing through the shaft to outside casing.

Figure 12 5-Blades Turbine

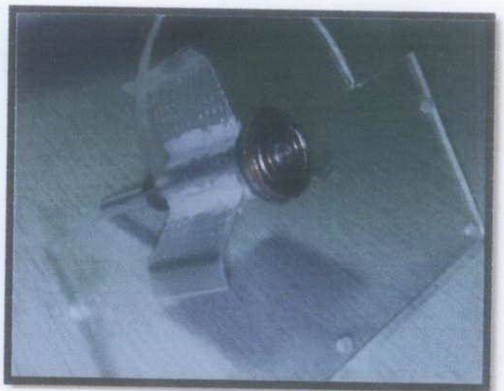

Figure 13 Bearing with 3-Blades Turbine

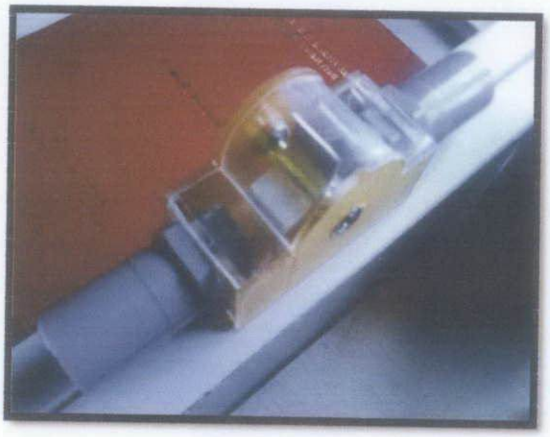

Figure 14 Turbine with Casing

3.5.3 Bearing and Shaft

A Bearing is a machine element which supports another moving machine element [16]. In this prototype design, bearing is used to ensure that the rotation of the turbine is smooth. It also will decrease the friction between the shaft and Perspex, and then it will increase an accuracy of the shaft alignment. Therefore, it will increase the rotational per minutes (rpm) of the turbine.

The shaft as in the picture above will be connected in between the turbine and the generator. The shaft will be placed in hole of the bearing as it will connect to generator. There is a hole at the shaft where we could join the shaft of the turbine with the shaft of the generator. Then, water flowing through the casing will produce kinetic energy and will be converting into electrical energy by the generator.

3.6 Proposed Generator (PMDC Motor)

For generator parts, a permanent magnet (PMDC) motor is selected in order to connect to the prototype design. The range of small DC motor with integrated gear train is design for applications requiring quality design and long life drive units. The motor has been designed with a permanent magnet stator system.

Figure 15 PMDC Motor

In selecting a motor for installation in this prototype, specification is very important in providing information in testing the motor and also to avoid motor from being damaged. The specified current rated values should not be exceeded. We use a 12 VDC motor as a generator in Micro Hydro Generator by considering the speed of motor and DC voltage supplied to the motor. In this motor, a lower torque is used to drive a high speed of motor.

3.7 Completed Prototype

After completing a design of turbine and its casing (during FYP1), the project progress is continue by designing and completing the overall design of Micro Hydro Generator. This overall prototype is including turbine and its casing, generator 12VDC as shown in Figure 16.

Figure 16 Completed Prototype of Micro Hydro Generator

Figure 16 shows the overall design of Micro Hydro Generator by combining generator into turbine casing and pipe for water flow without installing a circuitry part. Water from home pipeline will flow from top of the prototype, then will flow through the turbine and goes down into bottom pipe for drainage system.

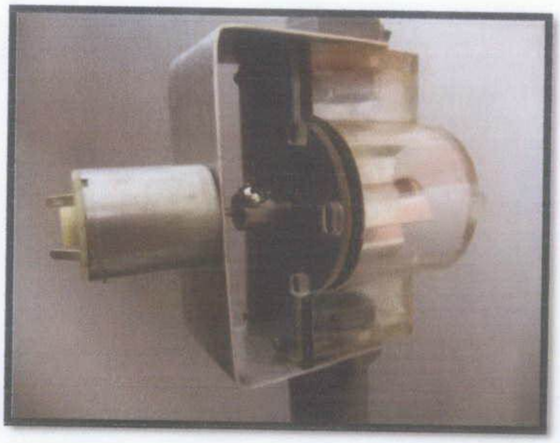

Figure 17 Turbine with Generator Installed

3.8 Conclusion

As a conclusion from this chapter, the design of micro hydro generator is fabricated completely. The design of the micro hydro generator is consists of turbine, casing and generator. A test and analyzing of the prototype will be handled to determine the performance of micro hydro generator.

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter will describe the tests and analyzing of the micro hydro generator to determine its performance. There are three main parts of experiments to test the performance of micro hydro generator which are open circuit test, turbine test and design test.

4.2Prototype Testing

4.2.1Open Circuit Test

A project progress is continued by conducting an open circuit test. This testing is conducted to determine the performance of DC generator that used for completing prototype design. For open circuit test, two identical DC generators are coupled together. One of the motor was connected to the power source to spin the motor and then move another motor's shaft, which represent as a generator in the system. The generator was connected to multimeter to measure the output voltage and output current. While conducting this testing, tachometer is used to measure the rotation per minutes (RPM) of the motor. Table 2 show the results obtained from the testing.

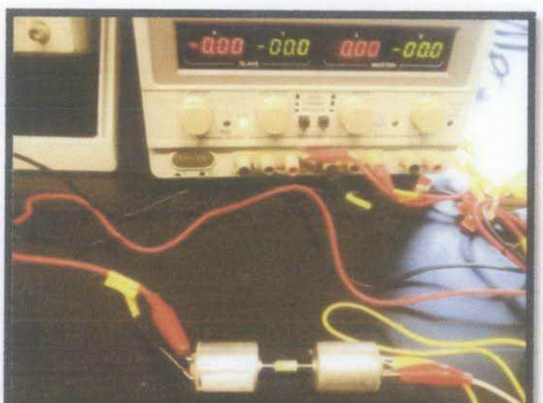

Figure 18 Setup for Open Circuit Test

Table 2 Result from Open Circuit Test

Input Voltage (V)	RPM	Output Voltage (V)	Output Current (mA)
0.0	0.0	0.00	1.00
0.5	0.0	0.00	1.00
1.0	0.0	0.00	1.00
1.5	0.0	0.00	1.00
2.0	214.5	0.94	2.00
2.5	322.0	1.50	3.40
3.0	431.0	2.00	5.10
3.5	520.0	2.48	6.10
4.0	625.0	2.99	7.40
4.5	717.0	3.47	8.20
5.0	819.0	4.01	9.30
5.5	917.0	4.45	11.00
6.0	1020.0	4.94	12.00
6.5	1107.0	5.35	13.40
7.0	1219.0	5.81	14.70
7.5	1290.0	6.34	15.20
8.0	1399.0	6.75	17.00
8.5	1490.0	7.20	17.70
9.0	1592.0	7.70	18.90
9.5	1681.0	8.12	19.80
10.0	1771.0	8.60	21.00
10.5	1867.0	9.09	22.30
11.0	1951.0	9.55	23.30
11.5	2044.0	10.00	24.40
12.0	2142.0	10.44	25.80

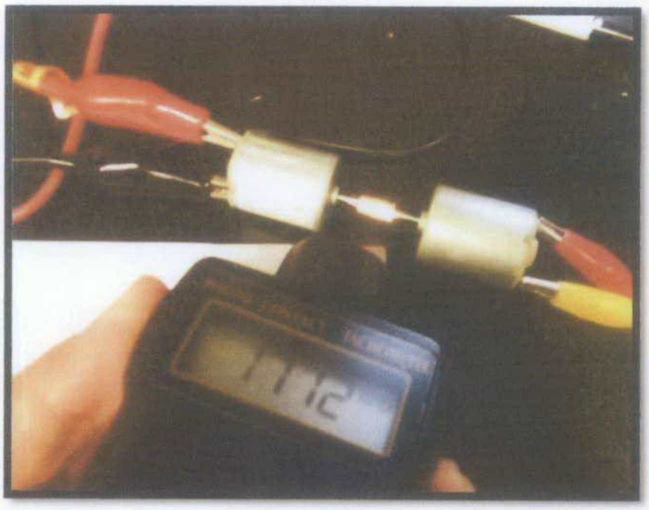

Figure19 Open Circuit Test

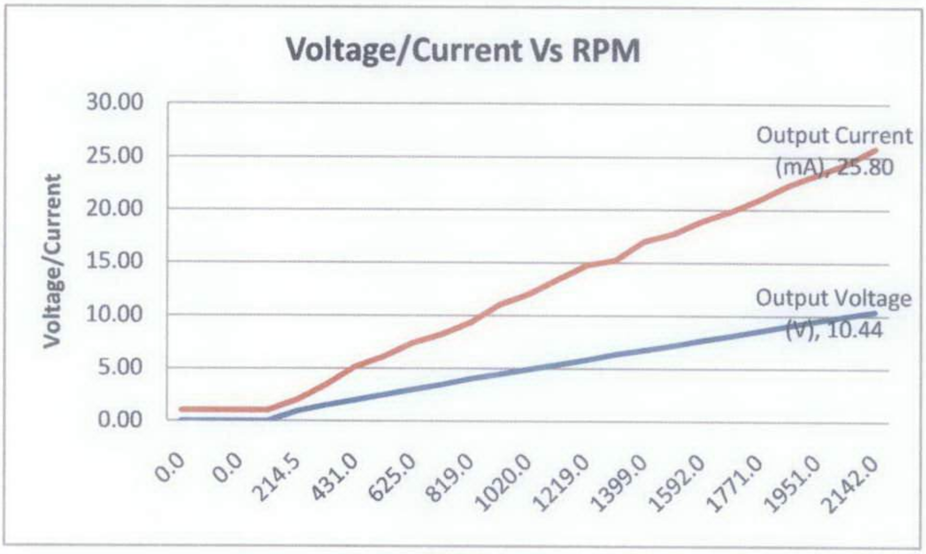

Figure 20 Graph Show Result from Open Circuit Test on Generator

Figure 20 shows the amount of voltage and current produced with different speed of generator. Based on the graph above, we can see that the voltage and current produced by the generator are proportional to speed of generator. At early stage, we can see in the graph, generator does not move until the voltage supply by power supply reaches about 2 V. This is because motor have minimum starting torque that required moving the motor. The data gain from this test will be use to determine the performance of the prototype.

4.2.2 Turbine Test

The prototype had been testing to determine the performance of Micro Hydro Generator. In completing this task, turbine speed test is conducted to determine the speed of the turbine using the flow rate of water from domestic pipeline. When the speed which is rotation per minutes (rpm) is determined, the voltage and current produced can be estimated for initial expectation result.

Figure 21 Turbine Test

Throughout the test, water from domestic pipeline is flow into the prototype. The rotation per minutes (rpm) is recorded using the tachometer. The result for both 3-blade turbine and 5-blade turbine for free rotation is recorded in the Table 3.

Table 3 Rotation per Minutes for Turbines

Turbine	**Rotation Per Minutes (rpm)**
3-Blade	1070.3 rpm
5-Blade	1137.7 rpm

The test is conducted for many times and average speed of turbine is measured. From the test the average speed of 3-blade turbine is 1070.3 rpm and speed for 5-blade turbine is 1137.7 rpm. Based on this result, 5-blade turbine is selected because has higher speed which more voltage can be generated. Increasing the number of turbine's blade will increase the speed of the turbine when conducting this test. From this result, estimation can be made based on the graph result of open circuit test where the generator can produce about 5.5 V and 13.7 mA by using 5-blade turbine.

4.2.3 Design Test

Voltage booster circuit test is conducted to see the battery storage can charging the hand phone. Through this test, a rechargeable battery is connected to voltage booster then the hand phone is connected from the voltage booster. The testing is shown in the Figure 22.

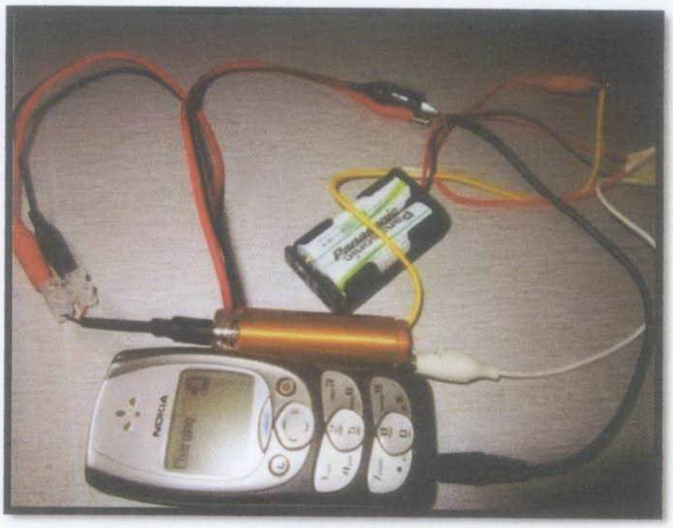

Figure 22 Booster Circuit Test

From the Figure 22, the rechargeable batteries supply 2.45 V to the voltage booster. A multimeter is used to measured output voltage from the voltage booster. The voltage produced from the voltage booster is 5.2 V. As in the picture, hand phone is charging by using rechargeable battery. The micro hydro generator will produced voltage and transfer to the rechargeable battery as an energy storage.

An overall design test is conducted on the complete design of the Micro Hydro Generator. The objective of this test is to determine the voltage and current generated from generator by using turbine blade as a mover. In this design test, generator is coupled to the turbine with casing by using a coupler. Water from home pipeline is entered into inlet of the prototype. This flowing of water will force a turbine to rotate the generator shaft. Flow of water supply mechanical power to generator, as the generator will produce voltage and current. Throughout this test, tachometer is used to determine the speed of turbine while multimeter is used to measured voltage and current produced by generator.

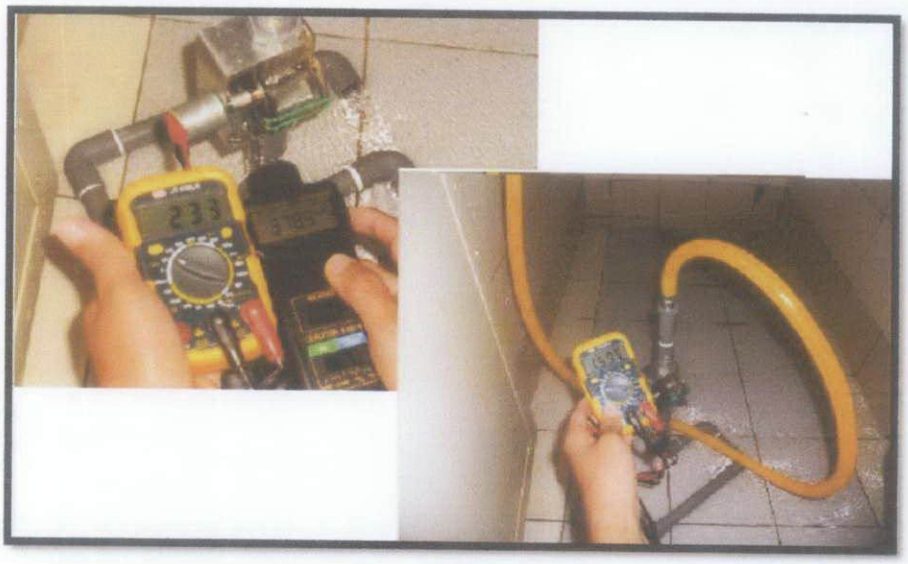

Figure 23 Design Test

From design test, the speed of turbine, voltage and current generated are obtained. Table 4 shows the result obtained from this test.

Table 4 Data Obtained from Design Test

Result	Reading 1	Reading 2	Reading 3	Average
Turbine Speed (rpm)	932	970.4	947.6	950.0
Voltage generated (V)	4.03	4.16	4.07	4.09
Current generated (mA)	10.0	10.51	10.24	10.25

According to the table above, the data is measured for three times and determine its average. The average values are determined because the readings are varying throughout the test. The changes of speed, voltage and current are due to the flow rate of water is not constant. Pressure of water is changing according to numbers of user using the water at certain time. Water pressure will decrease when the users are increased.

- *System Efficiency*

From turbine test and open circuit test, the speed of turbine is measured and the voltage and current produced is estimated by referring to open circuit graph result. The estimated maximum power generated can be determined is:

- Speed of turbine: 1137.7 rpm
- Generated voltage: 5.5 V
- Generated current: 13.7 mA

So, the maximum generated power is:

P = IV

= (5.5 V) (13.7 mA)

= 75.350 mW

Voltage and current produced when the speed of turbine is 950 rpm.

- Speed of turbine: 950 rpm
- Generated voltage: 4.65 V
- Generated current: 11.5 A

Power generated:

P = IV

= (4.65V) (11.5mA)

= 53.475 mW

Based on design test, the voltage and current generated is obtained. By using this data, output power generated by micro hydro generator can be calculated.

- Speed of turbine: 950 rpm
- Average generated voltage: 4.09 V
- Average generated current: 10.25 mA

The output power produced is:

$$P = IV$$

$$= (4.09 \text{ V}) (10.25 \text{ mA})$$

$$= 41.923 \text{ mW}$$

So, the efficiency of the Micro Hydro Generator is:

$$\text{Efficiency (\%)} = (\text{P generated} / \text{P max}) \times 100\%$$

$$= (41.923 \text{ mW} / 53.475 \text{ mW}) \times 100\%$$

$$= 78.397\%$$

4.3 Conclusion

Testing and analyzing on the prototype of micro hydro generator has been done completely. There are three tests has been conducted which are open circuit test, turbine test and design test. From these test, all the result obtained and analyzed. The performance of the micro hydro generator obtained from the data analyzing is 78.396%.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

As a conclusion, all the tasks are completed on schedule as planned in the Gantt chart. During semester 1, the objective of this project is partially achieved. Literature review has been conducted with various type of hydro generation technology such as impoundment, diversion and pumped storage system. Design has been proposed based on diversion technology. Some practical work had been conducted in completion of turbine design and casing of the turbine for development of micro hydro generator. The prototype of Micro Hydro Generator has been built which is consisting of turbine, shaft, bearing, casing and the DC generator. From testing and analyzing, micro hydro generator can generate voltage 4.09 V and current 10.25 mA. The performance of the prototype is 78.396%.During the test, it can charge battery for hand phone. The experimental work and data analysis is successful. The performance still can be improved by make some optimization of the prototype.

5.2 Recommendations

The performance of the prototype could be improved by modification and optimization of the design.

i) Optimize design of turbine

Based on the test, increasing the number of turbine blade will increase a rotation per minutes (rpm). As a recommendation, the turbine can be design by increasing the number of blade and test for their performance.

ii) Optimize design of inlet/outlet

Besides, the prototype also can be improved by modify the inlet and outlet of water flow through the casing. The pressure of water can be increased by decreasing the area of inlet and outlet of the casing. Hence, higher flow rate of water will strikes the turbine blades which can increase the speed of the turbine.

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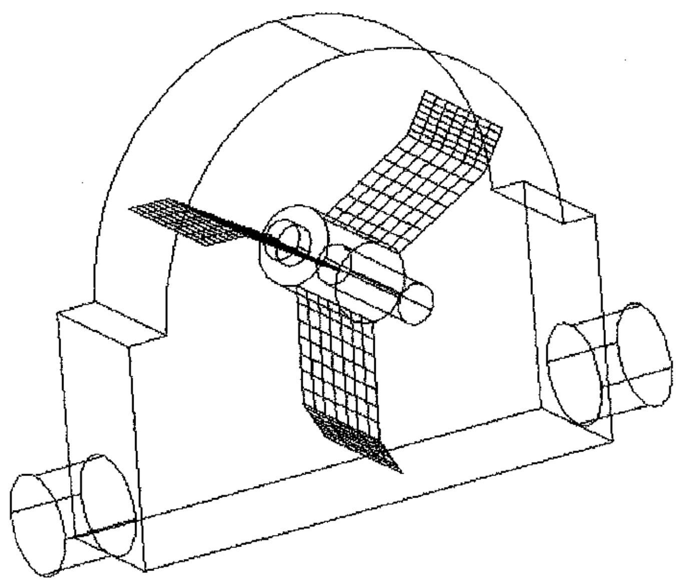
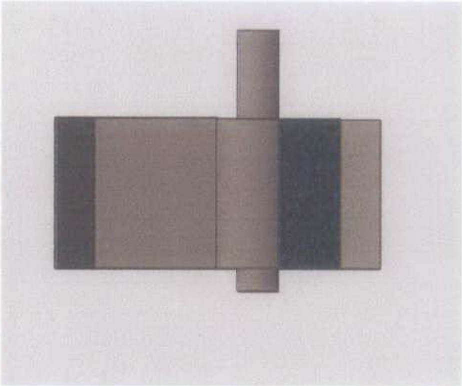
APPENDIX A

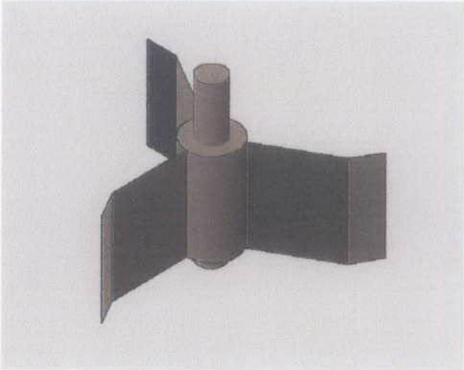
Engineering Drawing



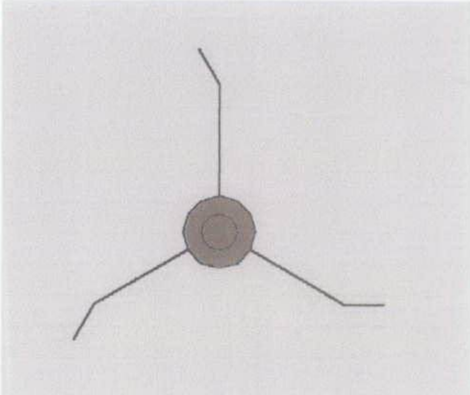
Overall Design



Side View

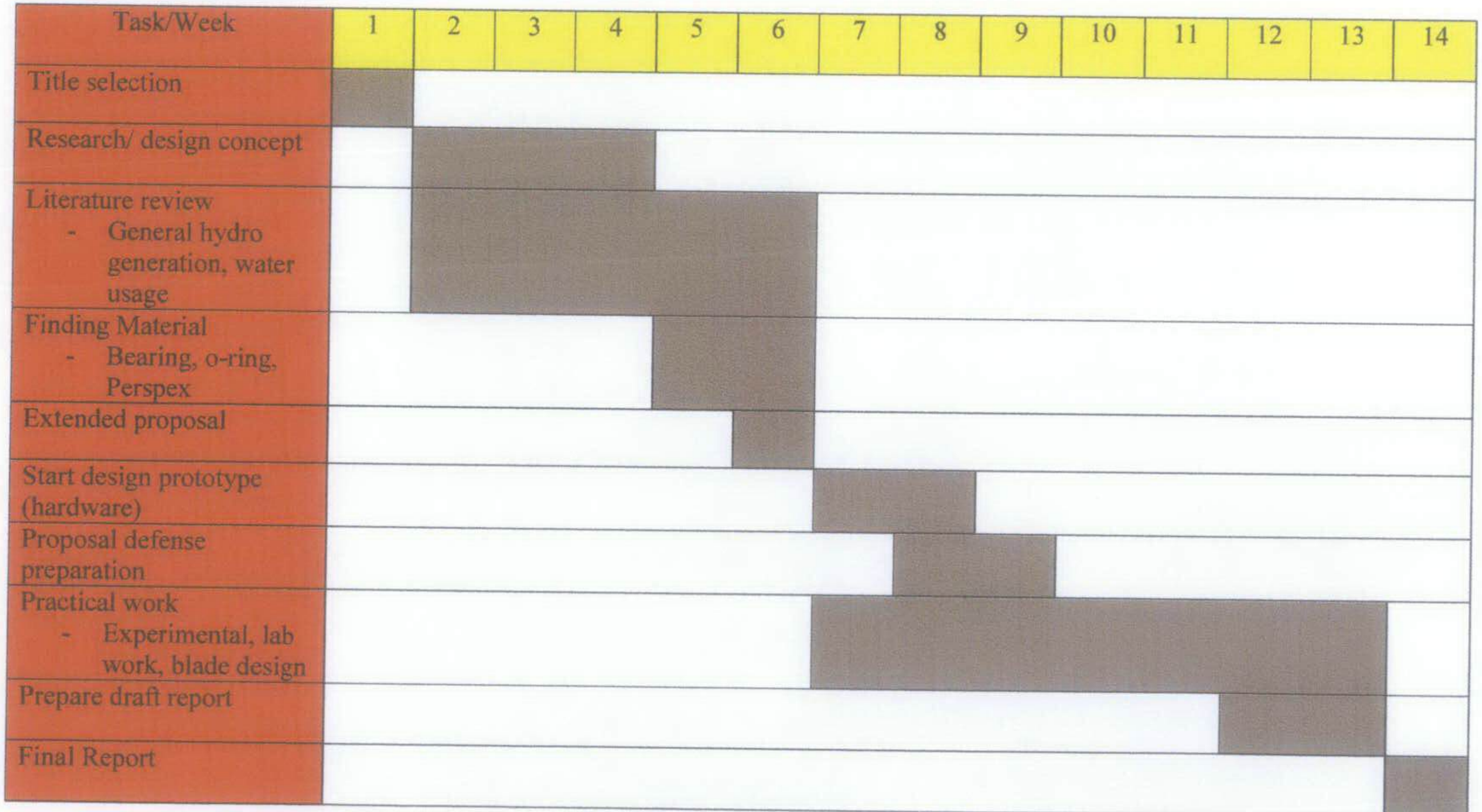


Angle View

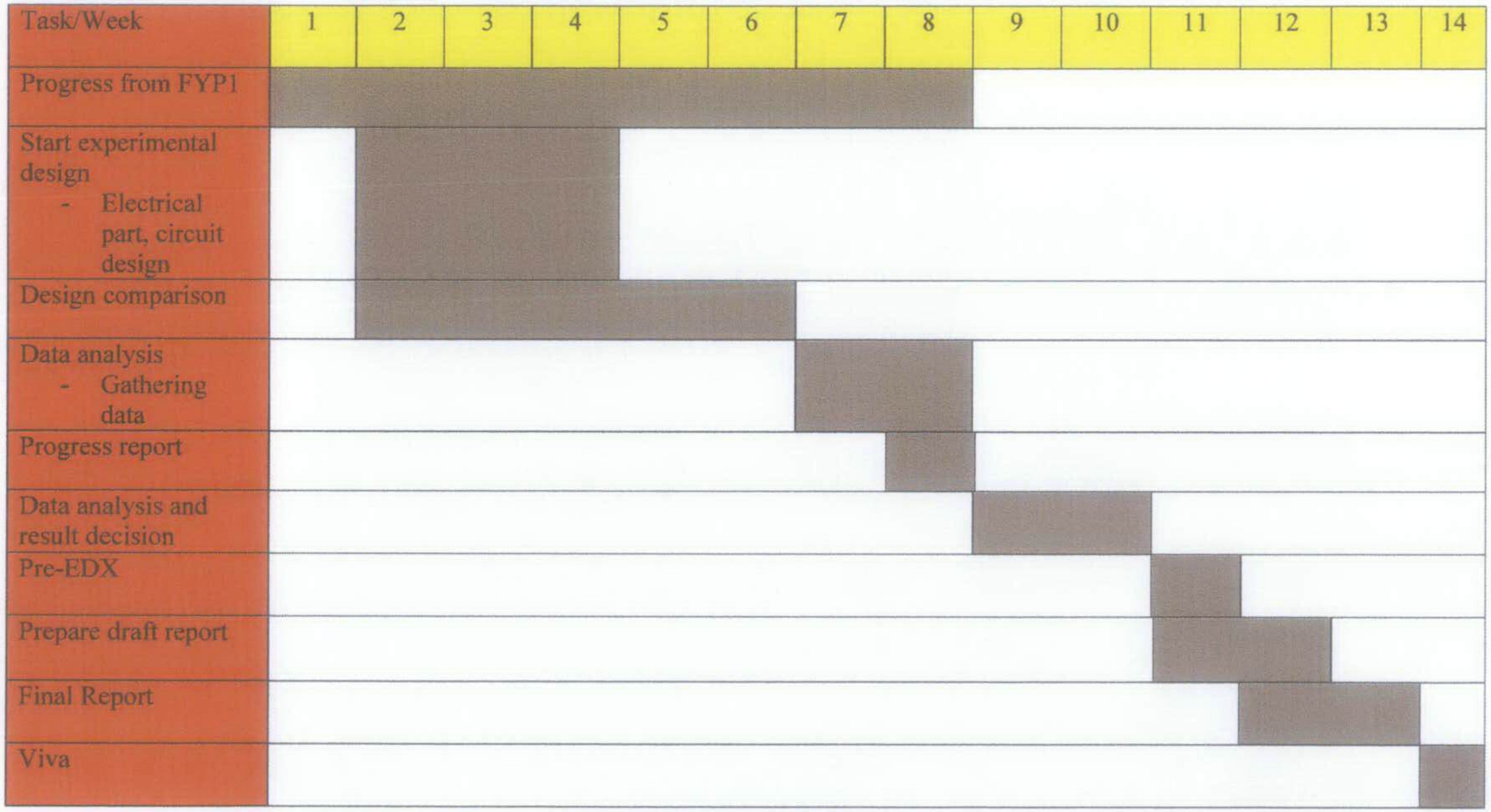


2-D View

Gantt Chart



FYP1- Gantt chart



FYP2- Gantt chart