Small Scale Water Wheel Powered Generator for UTP Mosque

By

Nik Mohd Hanif Bin Mohamed

Dissertation submitted in partial fulfilment of

The requirement for the

Bachelor of Engineering (Hons)

(Electrical & Electronics Engineering)

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CERTIFICATION OF APPROVAL

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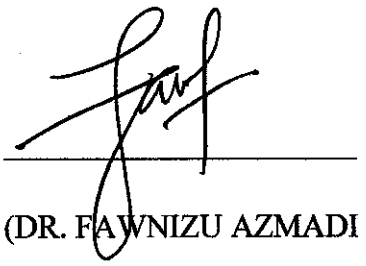
Approved by,



(DR. FAWNIZU AZMADI HUSSIN)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

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.

NIK MOHD HANIF BIN MOHAMED

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(ELECTRICAL & ELECTRONICS ENGINEERING)

ABSTRACT

This project is about the study of the feasibility of water wheel generator system at Universiti Teknologi PETRONAS mosque. To demonstrate the concept, the small scale water wheel prototype is constructed to test and analyse the feasibility of the water wheel generator. The water wheels utilize the flowing water from the upper part of the lake to the lower part, by capturing the potential energy of the water using the water wheel. This project can be divided into two main parts, first the mechanical part involve the design of the water wheel system and also small scale cascading. The second main part is the design of the electrical part and the selection of the most reliable and efficient DC generator to be attached to the water wheel body and the construction of the circuit which can store the generated power. The micro hydro system is an alternative method to reduce the usage and reliance on the grid power system which indirectly assists users to utilize the existing feature as a source of power generation.

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LIST OF ABBREVIATIONS

DC	**Direct Current**
AC	**Alternating Current**
PM	**Permanent Magnet**
PMDC	**Permanent magnet DC**
Rpm	**Rotational per minutes**
UTP	**Universiti Teknologi PETRONAS**

CHAPTER 1

INTRODUCTION

1.0 INTRODUCTION

1.1 Background of Study

Water is essential for life. No living being on planet earth can survive without it. Water has been used by human as a drinking water, watering plant and cooking. It is not only important as drinking water but it helps and bring so much useful to the activities in our daily life. It has been used in agricultural, industrial, household, recreational and environment activities. At a stream or river we can see water is flowing from one locality to another locality. However, do we realize that there are a lot of energy could be harness from the flowing water which we called water power?

Water power is generated by potential energy and movement of water. Water moves when there are energy instabilities. In other words, the level of energy changes through space. This is called energy gradient. For example, water on the surface of a table, it may form a puddle but the puddle won't move. If we tilt the table, the paddle will flow from the upper parts to the lower parts. Gravity is the driving force. The energy gradient is calculated by subtracting the higher elevation where the puddle started to where it stopped. The change in elevation alone is referred to as head. The steeper the gradient, the greater the driving force.

However the capability of the water as energy generator is not widely used around the world. Report has shown that only 2.2 per cent of the total energy source in the world is based on water [1]. The report included that the sources of energy highly depend on the non-renewable energy.

From 1990 till 2009, 87 per cent of total energy sources are coming from non-renewable energy.

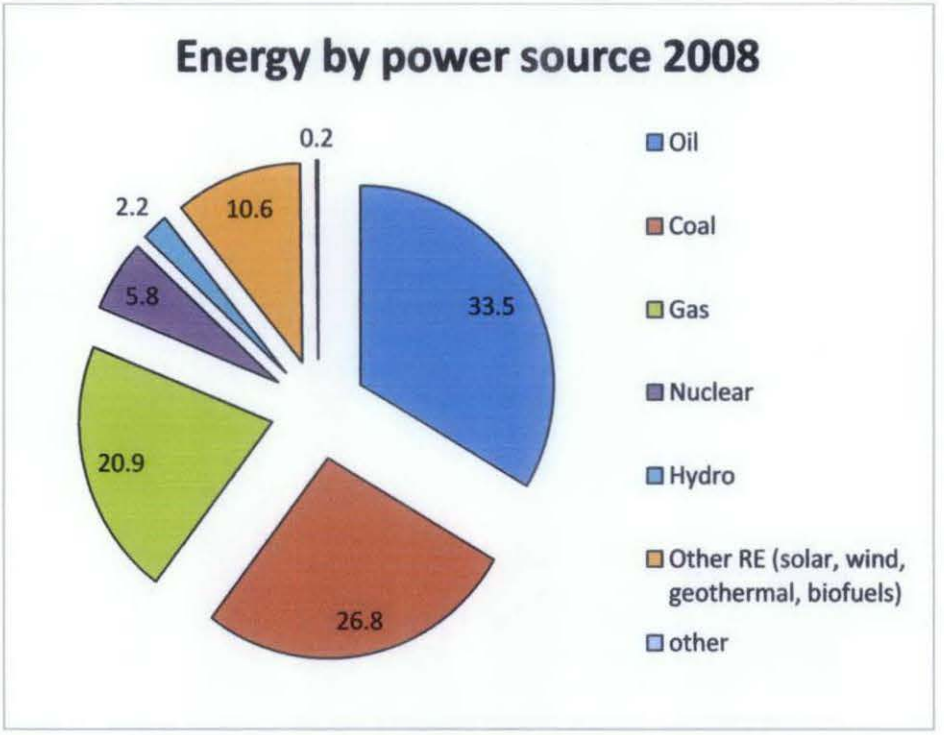


Figure 1.1: Energy by power source in 2008 [1]

The water can be actually fully utilized to produce electricity through a simple conversion of mechanical power to electrical power. This project is proposed to utilize water flowing to produce electricity from mechanical power to electrical power. Water wheel is a famous and simple solution to harness energy from water element. In Malaysia, specifically for this project at Universiti Teknologi PETRONAS, have a big potential to build water wheel station. As in UTP Mosque we have a cascading lake or weir for water wheel. The water wheel can be placed to along the consistent flowing water under the weir as it will produce the higher output of energy.

1.2 Problem Statements

Lake or pond has been chosen as one of water element for landscaping. Nowadays, there are many places like education institutions, residential areas, recreational areas, golf clubs and many more has constructed manmade lakes. One of the most famous lake concepts is developing water cascade. Basically the main objective of the construction is to derive the beauty element. However from the previous facts found that to operate the manmade lake consumes lots of power, equivalently results loss in money. The cost of building water cascade at UTP mosque spent more than RM 100,000. (AN-NUR Senior executive, 2011)

Therefore this project intends to utilize the cascading water at UTP Mosque as water power source. The idea is displayed by designing prototype of micro hydro generator which uses water flow to convert mechanical power to electrical power by installing a water wheel generator under the flowing water. Thus, potential energy produced can be harness instead of purely for beautification.

Figure 1.2: 3 metres water cascade at UTP mosque

1.3 Objectives

This project's objectives are:

1. To study feasibility of water generator at UTP mosque
2. To design a prototype of micro hydro generator system for water wheel.
3. To test and analyse the prototype of micro hydro generator system.
4. To design electric circuit for power generation storage.

1.4 Scope of Study

In order to complete this system, several scope of study had to achieve. The major scopes are as follows:

1. To get information and do some research about the UTP water cascade.
   - There will be a research toward the potential hydro energy of water at UTP water cascade
   - In obtaining the amount of energy produced, the flow rate of the water at the UTP mosque will be measured.
   - The dimension of water cascade is highly needed to complete the calculation of produced energy.
2. To get information about the type of water wheel to be attached and its efficiency.
   - The study of water wheel will determine the most reliable and efficient water wheel to be used in this project.
3. To design of the battery storage circuit accordingly to the generator output.
   - The purpose of designing is to store the generated energy in a proper medium.

1.5 The relevancy of the project

The aim of the project is to study the feasibility of water wheel system at UTP mosque and build a prototype of water wheel attached to water cascade system. The success of this project will provide a chance to support the existing power system. Other significant of the project is harness energy from be purely for decoration.

1.6 Feasibility of the project within the scope and time frame

As planned from the Gant chart and key milestone, the project is feasible to be run and can be completed within the time frame.

CHAPTER 2

LITERATURE REVIEW

This chapter includes the study of renewable energy, the power of moving water and water wheel engineering as an alternative energy. It also will go more on the selection of type of water wheel and the relevant electronics component and hardware.

2.1 The Background of Energy

Energy is used by us every day. Different forms of energy surround us such as heat, light, and electricity. The energy stored in molecules of substances like carbohydrates and protein is used by our body to move, think and grow. Energy also used by our body to work and play. Thousands of machines and appliances that use energy have been invented to make our work easier, and to transfer ourselves from one place to place. Some of these machines use electricity, while others like automobiles use the energy stored in substances such as gasoline or fuel.

"There are two most common forms of energy we use, which are heat and electricity. Heat is the energy of moving particles in any substance. The faster the particles move, the warmer the substance is. Electricity is the energy of electrons moving along a conductor like a copper electrical wire." [2] Most of the machines around us use either heat or electricity to do their work. A good example is portable fan. The fan uses an electric motor to turn the blade that blows air through.

Energy is easily converted from one form to another. This is an important and very useful asset, because we rarely produce energy using the same device, or in the same form as what is needed for the task at hand [3]. Since energy is often produced at some distance from its end use, we also need to convey it from its source location to where it is needed. This is done by means of wires in the case of electricity, or pipelines or tank trucks in the case of oil or natural gas. Not all forms of energy can be easily stored or transported. For instance, light is difficult to store directly. It has

to be transformed to some other form, such as chemical energy first. In general energy can be divided into two categories which are non-renewable energy and renewable energy.

2.1.1Non-renewable and Renewable Energy

Non-renewable Energy

Much of our energy supply comes from coal, oil, natural gas, or radioactive elements. They are considered non-renewable because once they are removed from the ground and used, they are not immediately replaced. In fact, the world's natural gas, crude oil and coal deposits took millions of years to form [4].

Uranium, which is used for nuclear energy, has limited supply as well. Humans will have used up most of these deposits in less than 200 years [5]. Once they are gone, non-renewable energy supplies cannot be replaced within short time.

Renewable Energy

Renewable energy on the other hand quickly replaces itself and is usually available in a never-ending supply. Renewable energy comes from the natural flow of sunlight, wind, or water around the Earth. With the help of special collectors, we can capture some of this energy and put it to use in our homes and businesses. As long as sunlight, water and wind continue to flow and trees and other plants continue to grow, we have access to a ready of supply of energy.

There are four common types of renewable energy which are:

1. Solar energy
2. Wind energy
3. Biomass energy
4. Hydro (Moving water)

2.2 Hydro energy

Hydro power is generated by using electricity generators to extract energy from moving water. Historically people utilized the power of rivers for agriculture and wheat grinding. Today, rivers and streams are re-directed through hydro generators to harvest energy.

Rivers are the most familiar form of water in motion, but there are also others as Ocean waves, waves, waterfall, and currents move unimaginable amounts of water around every day. Currents and waves are usually caused by winds blowing over the surface of the ocean, while tides are caused by the moon's gravity pulling gently on the earth. The action of waves, tides, and currents is especially noticeable near shores and islands, where they cause significant destruction.

Moving water is an important source of mechanical energy. Water is very compact compared to air, and flowing water carries with it far more energy than a similar volume of moving air. Humans have long appreciated the power of moving water, and have been using it for thousands of years. The types of hydro energy are separated according to their generated energy. The below table show the classification of hydro energy based on the amount of generated energy.

Large- hydro	More than 100MW and usually feeding into a large electricity grid
Medium-hydro	15-100MW – usually feeding a grid
Small-hydro	1-15 MW – usually feeding into a grid
Mini-hydro	Above 100kW, but below 1 MW; either stand-alone schemes or more often feeding into the grid
Micro-hydro	From 5kW up to 100kW; usually provided power for a small community or rural industry in remote areas away from the grid
Pico-Hydro	From a few hundred watts up to 5kW

Table 2.1: Classifications of hydro are made according to their generated energy [6]

2.3 Water wheel

Commonly there are two types of energy collectors for hydro energy which are turbine and water wheel. The oldest machine for capturing the energy of moving water was waterwheels. In the days before electricity, it was common to use water wheels to offer the power for mills that ground grain or cut lumber. To start the mill, the miller simply opened a gate to let the water flow over the top of the wheel. The water wheel was connected to a massive millstone or metal saw blade through a system of gears. Water for the wheel usually came from a small dam and reservoir, called the millpond

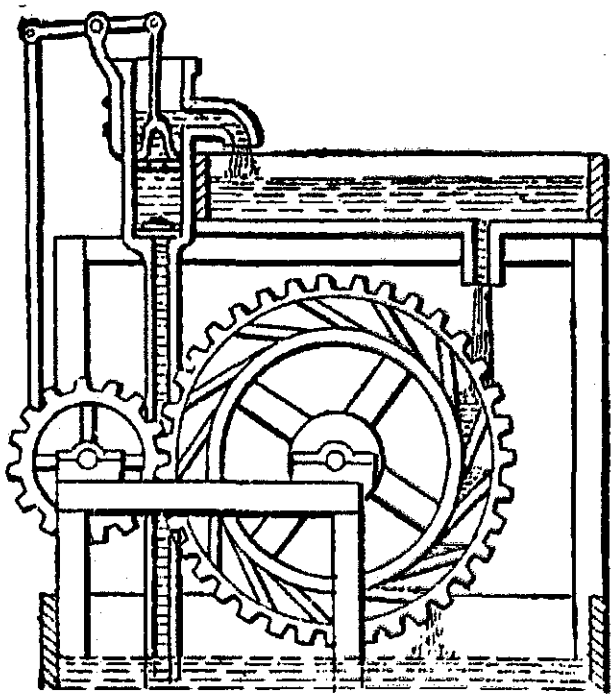


Figure 2.1: Perpetual-motion water wheel [7]

A water wheel is a machine for translating the energy or free-flowing water into useful form of water. A water wheel consists of a large wooden or metal wheel, with a number of blades or buckets arranged on the outside rim forming the driving surface. Most commonly, the wheel is mounted vertically on a horizontal axle. "The first description of a water wheel that can be categorically identified as vertical is from Vitruvius, an engineer of the Augustan Age (13 BC – 14 AD), who composed a 10 volume treatise on all aspects of Roman engineering. One of the most remarkable Roman applications of a water wheel was at Barbegal near Arles in southern France". [8]

2.3.1 Types of water wheel

Water wheel is the main part of project of small scale water wheel generator. It works when water passed Water-wheels; the rotation of the wheel is generating mechanical energy. Water wheel is fixed on a shaft, and the rotational motion of the wheel is transmitted by the shaft to a generator. Water wheels come in three basic flavours- under-shot, breast-shot and over-shot, with the former having two basic variants depending on the height of the water feed to the wheel [9].

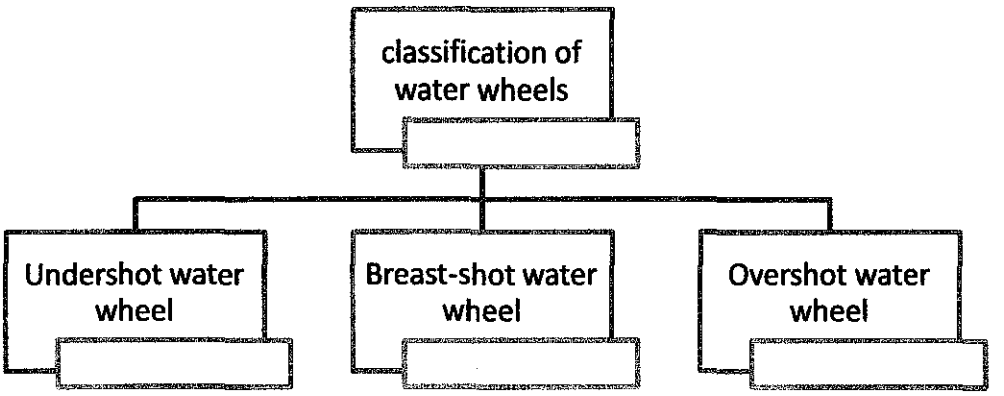


Figure 2.2: Classification of Water wheels

2.3.1.1 Over-shot

The over-shoot wheel has the water being feed in to the wheel disk at the top so as to collect in loads on the wheel causing the front of the wheel heavier than the rear. The weight of water causes the wheel to take turns forwards, emptying the buckets into the 'tail-water' stream which then flows on the sea or where-ever. High efficiency comes from full utilisation of the water flow which is directed into the wheel buckets with little or none flowing elsewhere.

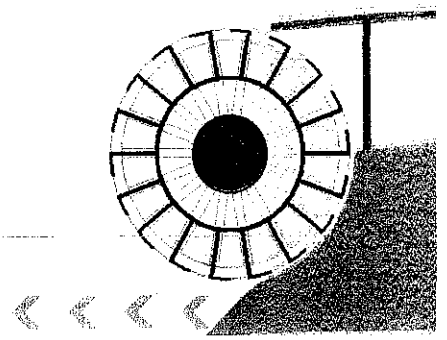


Figure 2.3: Overshot water wheel [10]

Based on the previous research found that, the water wheel with over-shot design provide the highest efficiency among those three designs with the efficiency is 60-85%.[11].

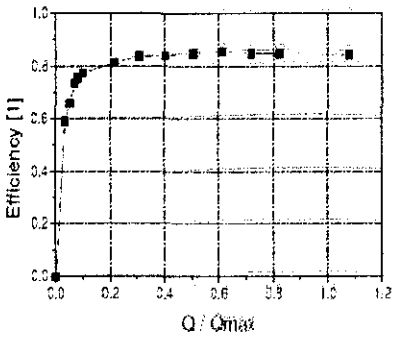


Figure 2.4: The efficiency curves for an over-shot wheel [12]

2.3.1.2 Breast-shot

The level of upstream water lies at approximately the level of the wheel's axis. This wheel type was used for head difference of 1.5m to 4m, and flow rates of 0.35 to 0.65 meter cubic per second per m width [13]. The water arrives the wheel with a rather steep angle, to ensure a rapid filling of each cell. The buckets are shaped so that the resultant force acts in the direction of the wheel's motion, and so that the cell walls exit the water downstream at a right angle, to evade losses at this point the weight of the water constitutes the driving force on the wheel.

The breast-shot will provide the efficiency around 50-85% [13].

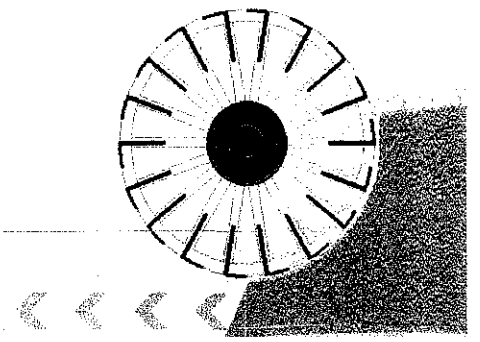


Figure 2.5: Breast shot water wheel [10]

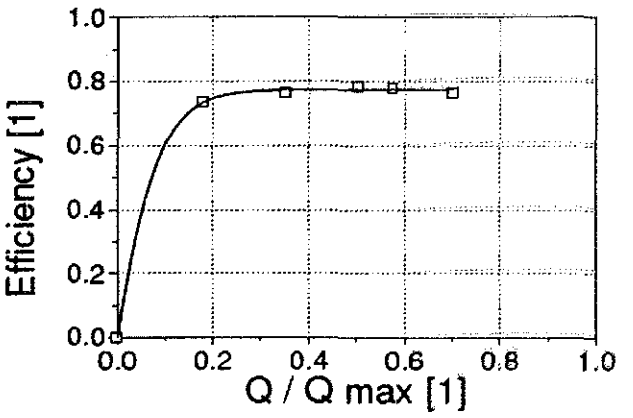


Figure 2.6: The breast shot wheel – model test. [13]

2.3.1.3 Under-shot

The oldest variant of the under-shoot is like a paddle on paddle streamer. It has its lowest extremities immersed in the flowing stream which causes the wheel to rotate backwards. It powered the English industrial revolution in its early stages until the advent of steam-power. A more efficient version of the under-shoot wheel has the water fed into the wheel a bit less than half-way up. The water feed channel continues to follow the curve of the wheel downwards to a point directly lower the axle where it flows into the tail water stream.

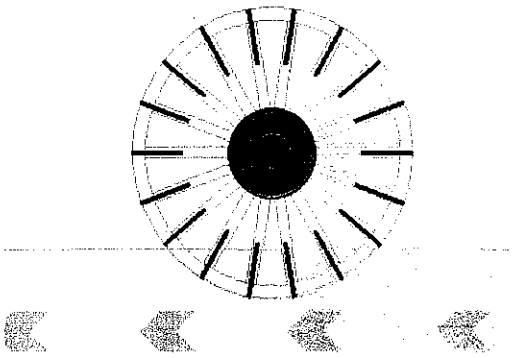


Figure 2.7: Undershot water wheel [10]

In order to investigate the efficiency if undershot wheels, some measurement were conducted by the technical University of Stuggart/Germany in 1977. The result of the test recorded the highest efficiency of undershot wheels is 77 % [14].

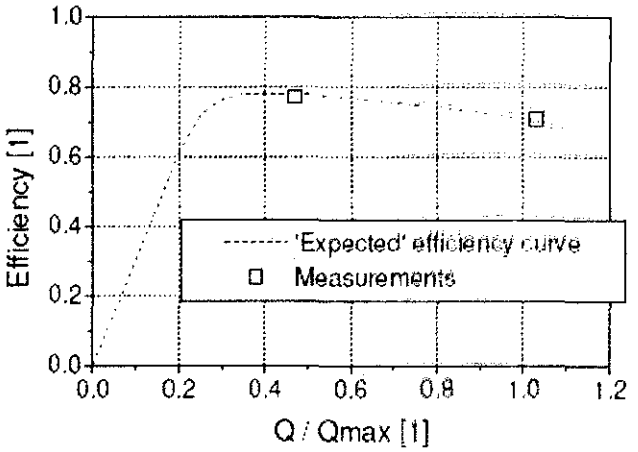


Figure 2.8: Efficiency of under shot water wheel [14]

2.3.2 Overshot design the most effectual design

The overshot wheel, as illustrated in Figure 5, consists of a series of buckets attached to the circumference of a wheel rotating in a horizontal axis. The water is admitted to these buckets at or very near to the crown of the wheel, hence the name overshot, in distinction from other types of water wheels, such as the central shot and undershot, the classification being made according to the point of an application of the water.

In the overshot wheel, the water acts principally by its volume. The water, which enters at the point A soon comes to a state of relative rest and by virtue of its weight turns the wheel, producing mechanical work equal to the product of the weight of the water times the vertical distance through which he waterfalls, while acting on the wheel. The wheel also performs some work due to the impulse effect of the water as it enters the wheel, but the amount is usually very small, since for efficient operation the velocity of the entering water must be low, in order to avoid excessive loss due to shock.

The problem then, for the designer, is to bring the water to a state of relative rest as high in the wheel as possible, and to have it remain in the wheel until it reaches the lowest point.

The advantages of the overshot wheel compare to other type of water wheel may be enumerated as follows:

1. High efficiency,
2. Adaptability to varying discharge,
3. Simplicity in construction,
4. Reliability

Of these advantages, the first two are of the greater importance. "Reports have been made of reliable tests of turbines yielding as high as 80 per cent, efficiency, but it is rarely that this figure is obtained in an actual installation. Especially in the smaller plants, where an overshot wheel would be capable of competing with a turbine, it is doubtful whether the turbines run with an average efficiency higher than 70 per cent. The installation of a turbine requires a technical analysis of the problem, and unless the turbine is set properly and selected for the particular conditions under which it is to operate, the efficiency will fall far below that of which it is to capable when operating under the proper conditions".[15].

2.3.3 Water wheel energy converts into electricity

It was proved that water wheels have surprisingly high efficiency for a wide range of flows. This has great advantage that power can be generated even from low flow volumes without complex control element as they are e.g. required for water wheel. The power/speed curves were also quite flat, indicating that speed control is not very crucial as long as the wheel operates approximately at design speed. The slow speed of water wheels means that gear boxes with transmission have to be employed.

To determine the power potential of the water flow it is necessary to determine both the flow rate of the water and the head through which water can be made to fall. The flow rate is the quantity of water flowing past a point in a given time. Typical flow rate units are litres per second or cubic meters per second. The head is the vertical height in meters, from the wheel up to the point where the water enters the intake area.

The potential power can be calculated as follows:

$$\text{Power} = \text{Head} \times \text{Flow} \times \text{Gravity} \quad [16]$$

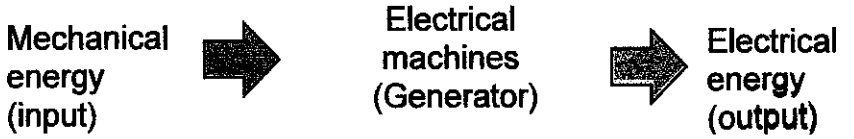
Where:

- power is measured in Watts,
- head in metres,
- Flow in litres per second, and
- Acceleration due to gravity in metres square (*(The acceleration due to gravity is approximately 9.81 meters per second per second)*

2.4 DC Generator

An electrical generator is a machine which converts mechanical energy into electrical energy. It is based on the principle of production of dynamically or motionally induced e.m.f (electromotive force). Whenever a conductor cuts magnetic flux, dynamically induced e.m.f is produced in it according to faraday's laws of

electromagnetic induction. This e.m.f causes a current to flow if the conductor circuit is closed. [17]



Generators are divided into two major categories depending upon the source of current i.e., Alternating current (AC) and Direct current (DC). Though the basic working principles of both these generators are similar, they differ in construction. These machines are also classified on the basis of the source of the mechanical energy by which they are powered, like water or steam power.

In this project, permanent magnet (PM) motor is chosen as the generator due to its suitability to the project. There are four type of PM motor, classified according to the manner in which their field flux is produced and this will affect the generator overall's performance in generating voltages and currents. Below shows the types of permanent magnet motor:

1. Permanent Magnet DC Motor (PMDC)
2. Permanent Magnet Brushless DC Motor
3. Permanent Magnet Brushless Synchronous Motor
4. Permanent Magnet Stepper Motor

Permanent magnet (PM) is chose as the DC generator due to its suitability to the project. The reason of choosing permanent magnet motor as the project generator in term of the features and the characteristics of the motor will be stated below.

2.4.1 Permanent Magnet DC Motor

A permanent magnet DC (PMDC) motor is a DC Motor whose poles are made of permanent magnets. PMDC motors offer a number of benefits compared with shunt DC motors as below [18]:

- Higher torque and output power per volume than when using electromagnetic excitation.
- Simplification of construction and maintenance.
- Reduction of process for some types of machines.

PMDC motors do not require an external field circuit, they do not have the field circuit copper losses associated with shunt DC motor. Besides that, since no field windings are required for PMDC motors, they can be smaller than corresponding shunt DC motors. PMDC motors are especially common in smaller fractional and sub fractional horsepower sizes, where the expense and space of a separate field circuit cannot be justified [19].

2.4.2 Characteristic of Permanent Magnet Motor

The speed of a DC machine operated as a generator is determined by the prime mover. In this project, the prime mover is the water flowed from the water cascade and the generator is connected to the water wheel so that the load of the generator is constant. Under such condition, the generator performance deals primarily with the relation between terminal voltage and current and the speed of the generator. These relations can be best exhibited graphically by means of curves known generator characteristics. These characteristic shows at a glance the behavior of the generator under different speed conditions.

2.5 Battery charger

In this project, energy generated is stored in a battery. Hence a battery charger is needed to be constructed to collect the energy generated before the energy is distributed. A battery charger is a device used to put energy into a secondary cell or rechargeable battery by forcing an electric current through it. There are many type

of battery charger which are simple, trickle, time-based, intelligent, fast, pulse, USB-based, solar charger and motion-powered charger. The different between these chargers are the input of the charger.

During charging, the positive active material is oxidized, producing electrons, and the negative material is reduced, consuming electrons. These electrons constitute the current flow in the external circuit. The electrolyte may serve as simple buffer for ion flow between the electrodes, as in lithium-ion and nickel-cadmium cells, or it may be an active participant in the electrochemical reaction, as in lead-acid cells. Charging process usually takes from a few minutes to several hours to charge a battery.

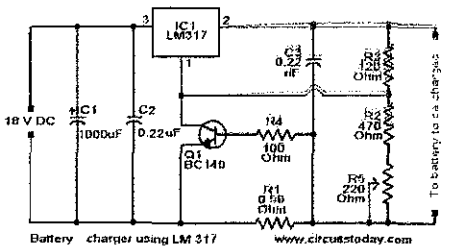


Figure 2.9: Sample of battery charger circuit [20]

CHAPTER 3

METHODOLOGY

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, and article, any relevance information is collected. This research is important to make more understanding on what the project is all about.

3.2 Key milestone

The key milestone is divided into two terms:

1. Key milestone for FYP I
2. Key milestone for FYP II

For key milestone in FYP I:

- Submission of Extended Proposal (week 6)
- Proposal defence (week 8)
- Submission of Interim Draft report (week 13)
- Submission of Interim report (week 14)

For key milestone in FYP II:

- Submission of Progress report (week 8)
- Pre-EDX exhibition (week 11)
- Submission of Draft report (week 12)
- Submission of Dissertation (soft cover) (week 13)
- Submission of technical paper (week 13)
- Oral presentation (week 14)
- Submission of dissertation (hard cover) (week 15)

3.3 Project activities

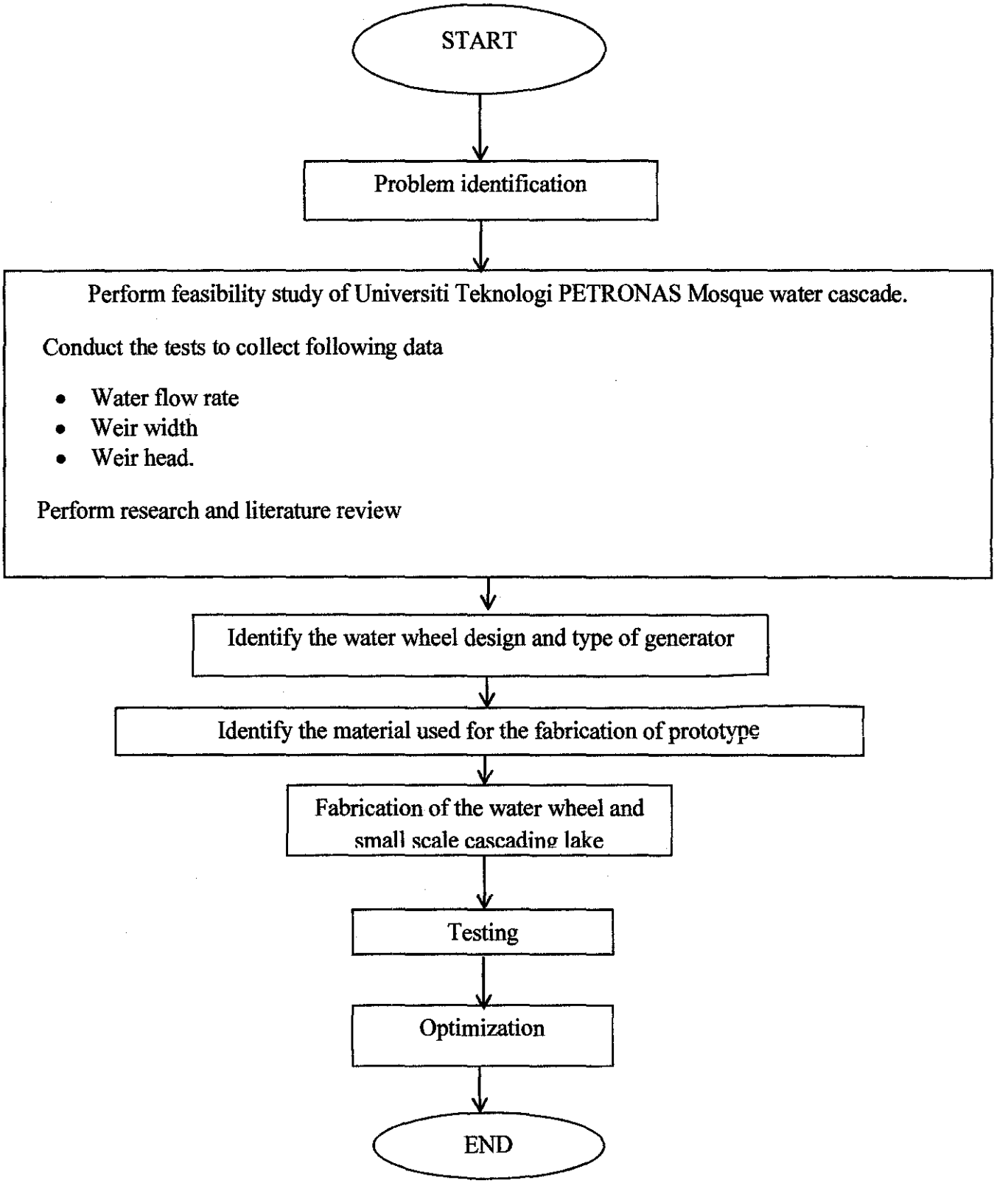


Figure 3.1: Flow Chart of Project in Semester I

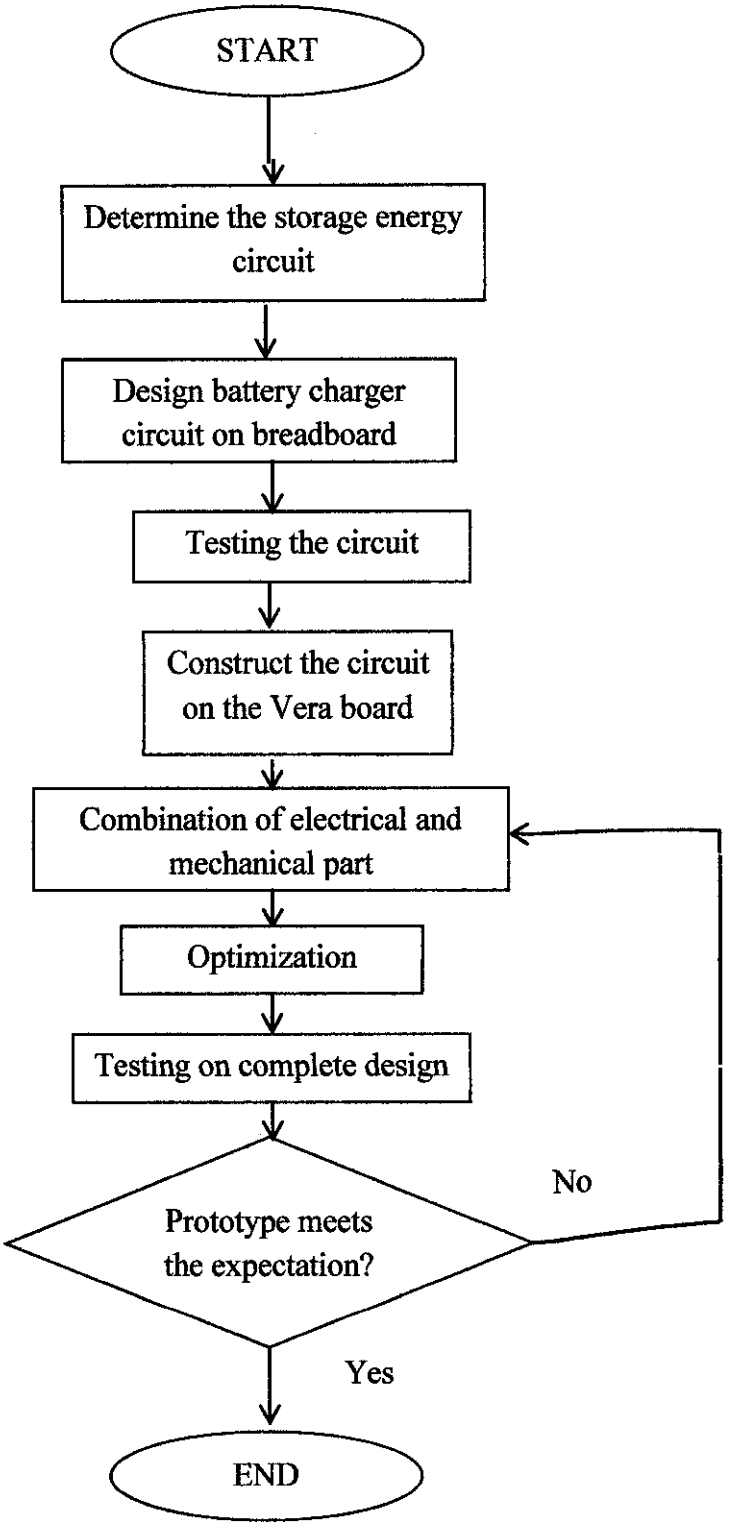


Figure 3.2: Flow Chart of Project in Semester II

3.4 Tool & Equipment

Tools	Equipment	Materials
Allen keys	Mining machine	Acrylic Perspex
Plier	Drill machine	Aluminium sheet
Hammer	Grinder machine	O-ring
Metal Cutter	Tachometer	Ball bearing
Perspex Cutter	Multi meter	Aluminium rod
L ruler	Power supply	Silicon glue
Vernier scale	Stop watch	4mm screw
Saw		Chloroform liquid
Long nose		
Soldering Iron		

Table 3.1: List of tools

3.5 Data Gathering

Small scale water wheel generator is aimed to be installed at Universiti Teknologi PETRONAS mosque, hence all data regarding the water and electric consumption is needed. Flow rate of water flowing at the mosque and the head gross is important in determining the voltage generated. Hence, an interview is held to gather data of water flow rate and its head gross at UTP mosque.

3.6 Laboratory Work

For semester 1, some investigation is needed to determine the flow rate of water. This is useful to estimate amount of power generation. Besides, for the prototype, open circuit test and external test are used to check the performance.

In semester 2, experimental work is needed for further improvement of the project. In mechanical part, a coupler is using instead of gear to maintain the stability of the prototype. Electrical circuit has been constructed and testing during semester 2. The experimental test has been run to check the functionality of the circuit to store the generated energy. The wheel test and full design test has been run to check the performance of the prototype.

3.6.1 Flow Rate measurement

To measure the flow rate of the water at UTP mosque, bucket method test has been run. The bucket method is a simple way to measure the flow rate using household items. To run this test, stopwatch and a large bucket is needed.

Listed below are the procedures to run the bucket method test.

1) Measure the volume of the bucket or container.
2) Find a safe location along the waterfall.

3) With a stopwatch, time how long it takes the waterfall to fill the bucket with water. Start the stopwatch simultaneously with the start of the bucket being filled and stop the stopwatch when the bucket fills.
4) Record the time it takes to fill the bucket.
5) Repeat steps two and three about five or six times and take the average.
6) The flow rate is the volume of the bucket divided by the average time it took to fill the bucket.

For the prototype, the flow rate is measured using the same method.

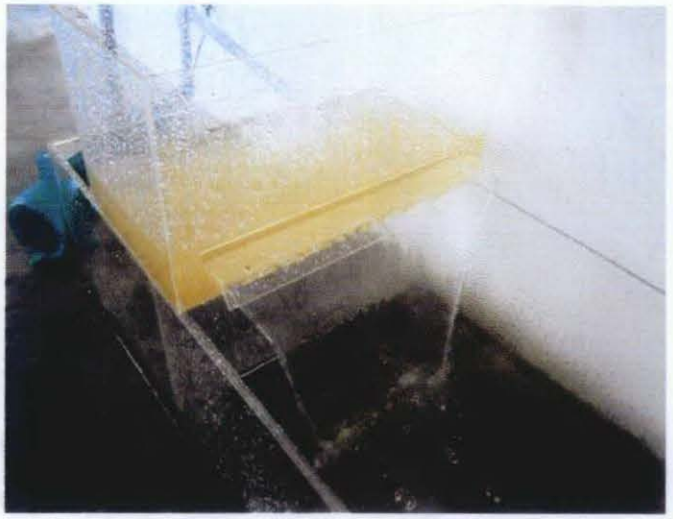


Figure 3.3: Prototype of water cascade

3.6.2 Open Circuit Test

Previously it have been discussed the function of generator which converts mechanical to electrical energy. On the other side, motor is functioning in reverse process of generator. Open circuit test is conducted using two dc motor. The first motor will act as the motor and another motor will be the generator. The generator and motor will be connecting together, if the motor is supplied by some power it will spine and simultaneously will turn the generator (second motor). Figure show the connection of open circuit test.

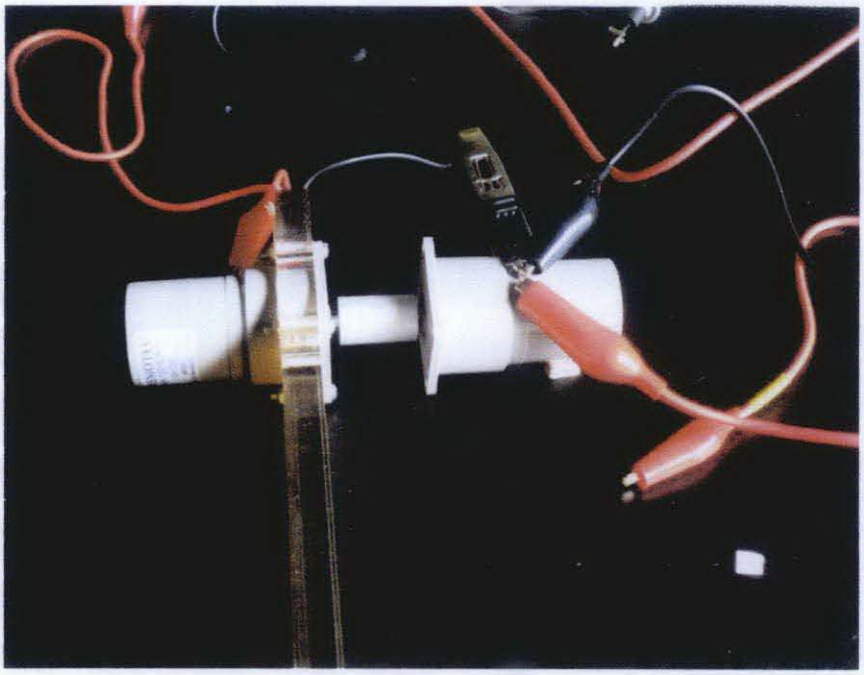


Figure 3.4: Connection of motors for open circuit test

The EMF of motor will be tested with various speeds. As the voltage supplied to the motor is changed the speed of the motor will be changed. The speed of the generator can be measured using tachometer. As the speed of the generator is varies, the voltage and current generated is recorded. Figure 3.5 and 3.6 show the measurement of open circuit test when the speed of generator is 218.5 rpm.

Figure 3.5: The Multimeter shows the measurement of voltage generated

Figure 3.6: Measurement of generator speed using tachometer

3.6.3 **Coupler installation**

To connect the water wheel with DC generator, a coupler is used instead of gear. Installation of coupler to the wheel is able to increase the stability of the water wheel. The higher the speed of the generator shaft, the more power can be generated. The figure 3.7 shows the connection of wheel and DC generator using a coupler.

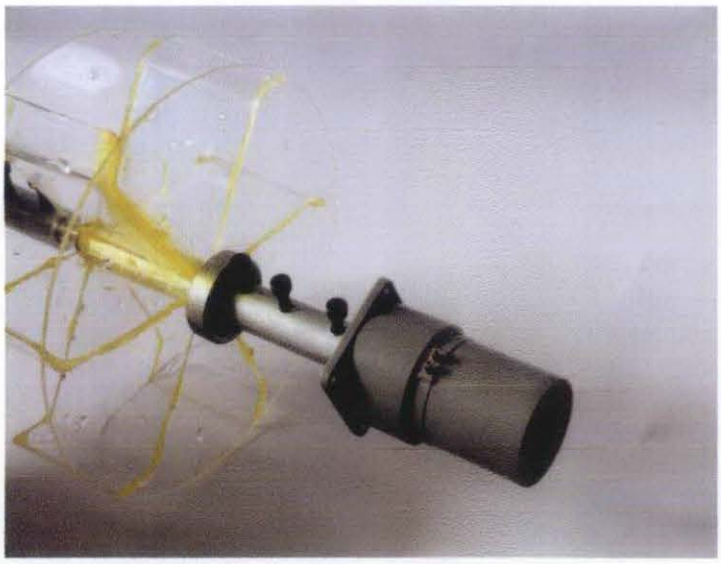


Figure 3.7: The coupler is used to attach water wheel and DC generator

3.7 Water Pump

For this project, water cascade is made to make it is real as the situation at the UTP mosque. The water cascade is built using a high performance water pump. Two layer water cascade need moving water in order to function. A water pump is the device that helps fountains creates the beautiful and constant running water. The water pump used for the project is shown in figure 3.8 .The specifications of the water pump are listed in table:

Figure 3.8: 1HP Water pump

Brand	PRECISION
Qmax	50l/min
Hmax	40m
Suct.Hmax	9m
Size	1" x 1"
Voltage	230-240~
Power	1.0 H.P/ 0.75 kW
Thermal Protection	Yes

Table 3.2: The specifications of Precision water pump

The concept how the pump play the role is illustrated, as showing in figure 3.9.

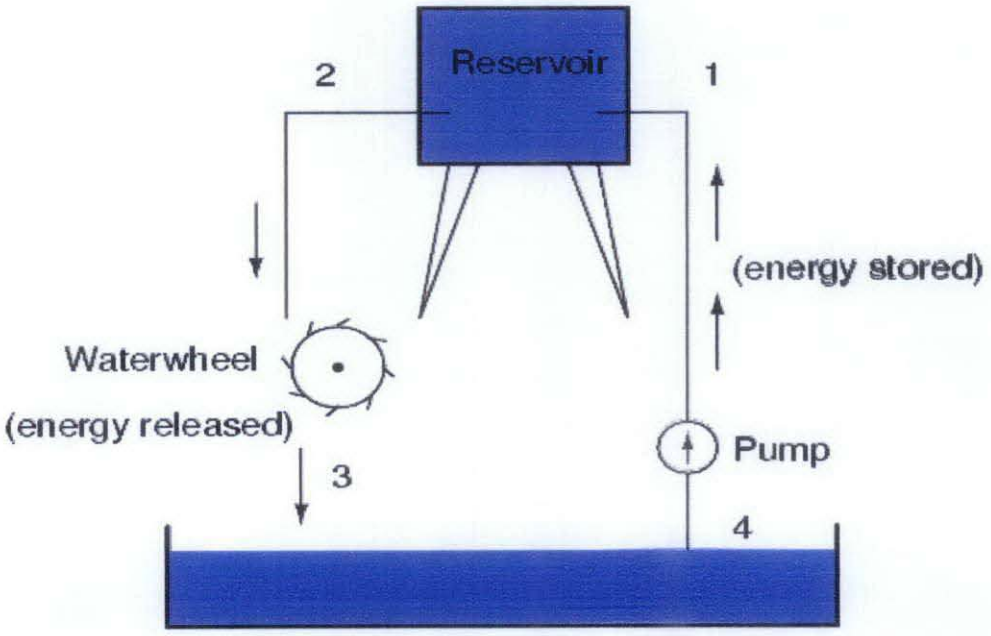


Figure 3.9: water pump is used to lift up water

CHATER 4

RESULT AND DISCUSSION

4.1 Data Gathering

Water wheel generator is aimed to be used at the lake of UTP mosque hence all data regarding to the water and electric consumption is needed. Volume of water flowing from the top layer of lake and its velocity is important in determining the power generated. Electricity consumption also worthwhile to make a comparison, hence an interview is held to gather the data of electricity consumption.

An interview had been conducted to department of electricity maintenance UTP to get some information on the electricity consumption. According to Ir Mohd Fatimie irzaq, the power rating for lighting system in front of the mosque park is 30 A. the number of power consume at the mosque is not available as there are no measurement is placed. The UTP power station supplies the unlimited power to mosque every day.

In term of volume and velocity of water flowing from the water cascade, some research had been made and the results are show below.

Water cascade at UTP

Width of weir: 50 meter

Head on the weir (from water surface): 3 meter

To calculate the value of water flow rate, bucket method has been conducted:

Using the distance of 1 meter, the flow is measured. The 1 meter of width is representing the width of water wheel.

Bucket Method Data for Flow rate		
Trial Number	Time,t (Seconds)	Bucket Volume,V (Liters)
1	6.9	10
2	7.9	10
3	7.5	10
4	7.1	10
5	7.5	10
Average	7.38	10

Table 4.1: Bucket Method Data for flow rate for UTP water cascade

Using the data, the volumetric flow rate (Q) is equal to the volume of the bucket (v) divided by the average time (t)

$Q = v / t$

Where t = (6.9+7.9+7.5+7.1+7.5) sec / 5trials

T = 7.38

Q = 10/7.38 = 1.36 liter/sec

= 81.60 liters/minutes

Flow rate = 81 liters/min (for 1 meter width)

The flow rate for the prototype also has been measured by the same method: table below show the data obtained.

The flow rate of water for 0.05 meter width (width of prototype wheel) is recorded in the table below.

Bucket Method Data for Flow rate		
Trial Number	Time, t (Seconds)	Bucket Volume, V (Liters)
1	7.15	1
2	6.59	1
3	9.2	1
4	6.43	1
5	6.33	1
Average	7.14	1

Table 4.2: Bucket Method data for flow rate for prototype

$Q = v / t$

Where t = (7.15+6.59+9.2+6.43+6.33) sec / 5trials

T = 7.14

Q = 1/7.14 = 0.14 liter/sec

= 8.67 liters/minutes

Flow rate = 8.67 liters/min (for 0.05 meter width)

4.2 Prototype construction

The diagram below has shown the idea of the project with the smaller size. The two layer acrylic containers exemplify the layer of the lake at UTP Mosque. While the water pump is the device that helps fountains creates the beautiful and constant running water. The water pump used is representative for the 4 pumps used in weir system at the UTP mosque lake. The output water from the lake top container (reservoir) which is the weir system will be the input for the wheel to turn henceforth turns the dc generator to generate some power output.

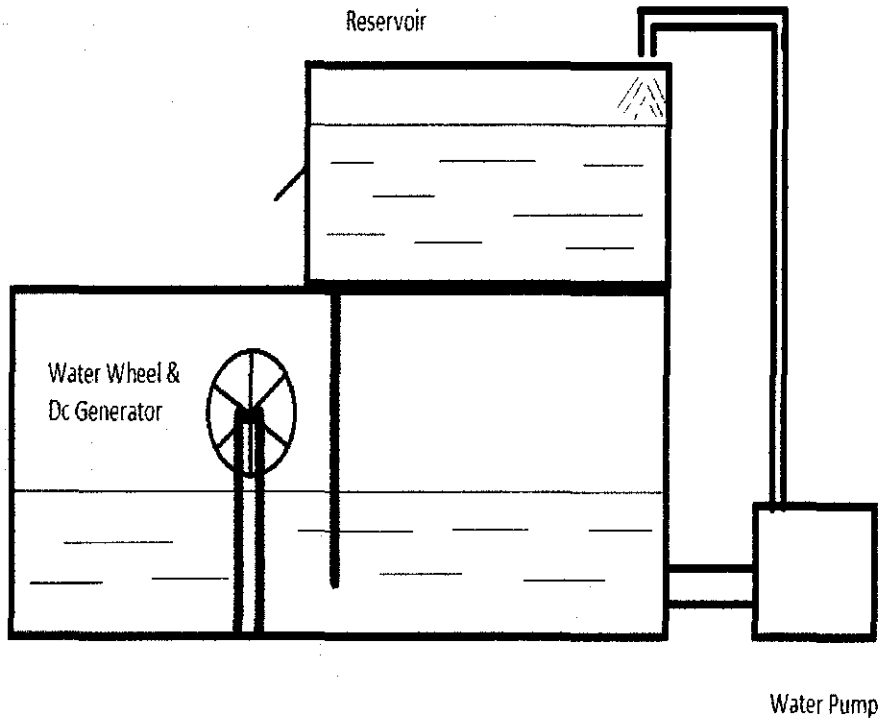


Figure 4.1: Small scale water wheel prototype

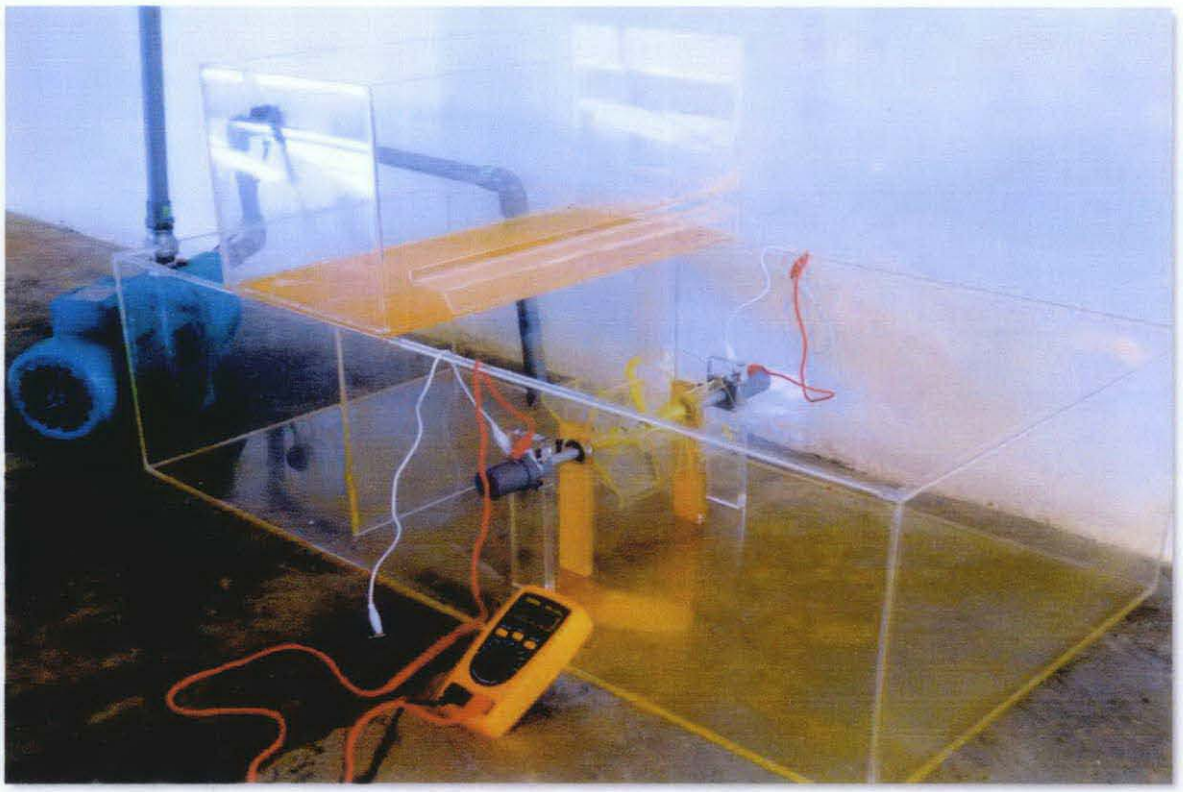


Figure 4.2: Small scale water wheel prototype

Water wheel and generator are the two main parts in prototype construction. The performance of the project are mainly depends on the wheel and generator used in the project. Hence some discussion and decision making on the wheel and generator are included in the following parts.

4.2.1 Design of water wheel

Water wheel for this project is designed instead of selecting a complete turbine sold in the market. For prototype version of water wheel is made from 2mm acrylic sheet. The design of wheel and shaft and the usage of the O-ring and bearing will specified as below.

The blade of the wheel had been made curve in order to increase the speed of the water wheel as the water flow directly on the blade surface. The speed thus will increase the rotational per minutes of the water wheel. Besides that, the curve also important in order to catch more water as water flow through the wheel. This will help the wheel to increase the torque to rotate the wheel.

There are six blades for a wheel, it have been constructed to have many blades as it easier for the wheel to catch the flowing water. The result of the wheel test in show rotation per minutes for a wheel is increasing when the numbers of blades are increasing.

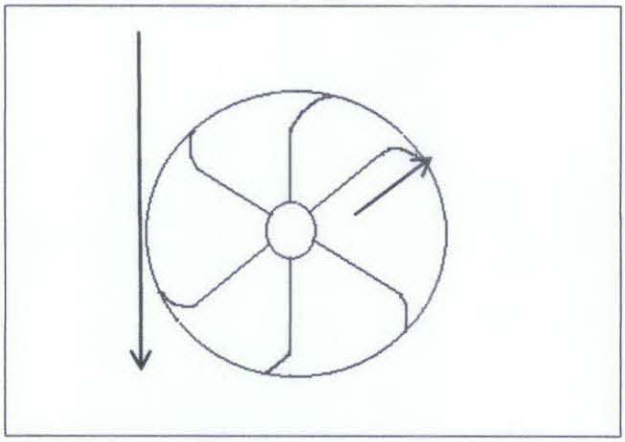


Figure 4.3: Drawing of water wheel

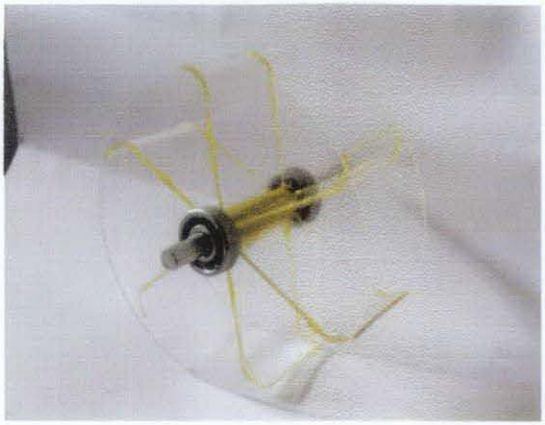


Figure 4.4: water wheel with curve shape blades

The usage of bearing is important in order to ensure that the rotation of the wheel is smooth also decrease the friction between the shaft and the acrylic sheet. This addition will increase the rotational per minutes of the water wheel. It is also could stabilize the wheel.

The shaft is connected in between the wheel and the motor. Then, there is a coupler which connects the shaft of the wheel with the shaft of the motor. Hence, the kinetic energy from the shaft will be converting into electrical energy by the dc motor.

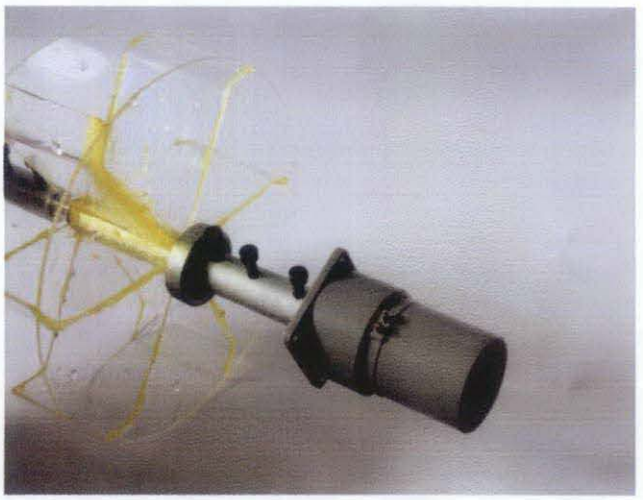


Figure 4.5: Connection between the wheel and motor using aluminum coupler.

To make the wheel receive the water flowing firmly, two stands is built to hold the wheel. Figure 4.6 below showing how the stand is connected to the wheel

Figure 4.6: Water wheel with stand

4.2.2 Proposed DC motor

The second main part of the project is DC generator. The selection of the motor or dc generator is depending on the torque and the output voltage. Besides that, other specifications also are considered such as dimensions, weight and rated

current. For the prototype 12VDC generator with maximum rotation of 330 rpm is selected. Justification of this decision is made by considering the speed of the motor and the DC voltage supplied to the motors. In 12 VDC generator, a lower torque is used to derive a high speed of motor. Besides that, 12 VDC generator has higher DC voltage which is 12 VDC and it allows the generator to generate voltage up to 12V instead of 6V. Figure below show the comparison of the 12 VDC generator and 6 VDC generator.

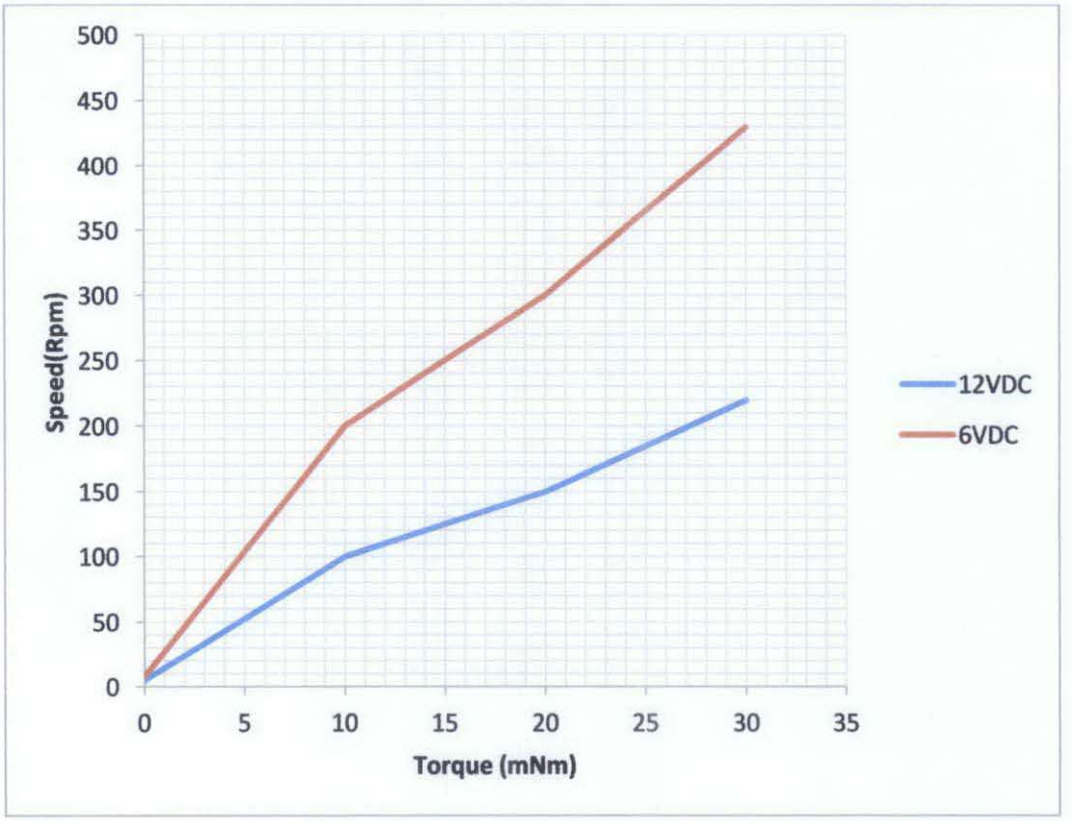


Figure 4.7: Performance of 12VDC Motor and 6VDC Motor.

The image of the dc generator and its specifications are shown below:

Figure 4.8: 12VDC Generator

Item	Description
Direction of rotation	Reversible
Rotor	Iron core
Power rating	2.2 W
Rotational Speed Max:	310rpm
No Load Speed	330rpm
Torque Max	0.0025N-m
Supply voltage Range	12V to 14.4V
Supply Voltage Max	18V
Nom Operating Voltage	12V
Current Rating	45mA
Reduction ratio	9:1
Operating Temperature Max	60°C
Operating Temperature Min	-20°C

Table 4.3: the specification of the motor

Dimensions

Criteria	Details
Shape	Cylindrical

Body diameter	38.6mm
External Height	65.5mm
External Diameter	38.6
Flange Length	39mm
Flange Width	39mm
Shaft Diameter	4mm
Shaft Length	8.5mm

Table 4.4: Dimension of DC Generator

4.3 Experimental result

There are five experiments to test micro hydro generator of water wheel. There are flow rate measurement test, open circuit test, external test, wheel test, design test, and battery charger circuit test.

4.3.1 Open circuit test

Open circuit test is conducted by coupled two motor together. In figure 4.9, it shows the setup test and the testing for open circuit test. Voltage is supplied to the first motor to supply mechanical power to the second motor which acts as generator. The generated voltage and current are measured using Multimeter. While the speed of shaft generator is measured using Tachometer.

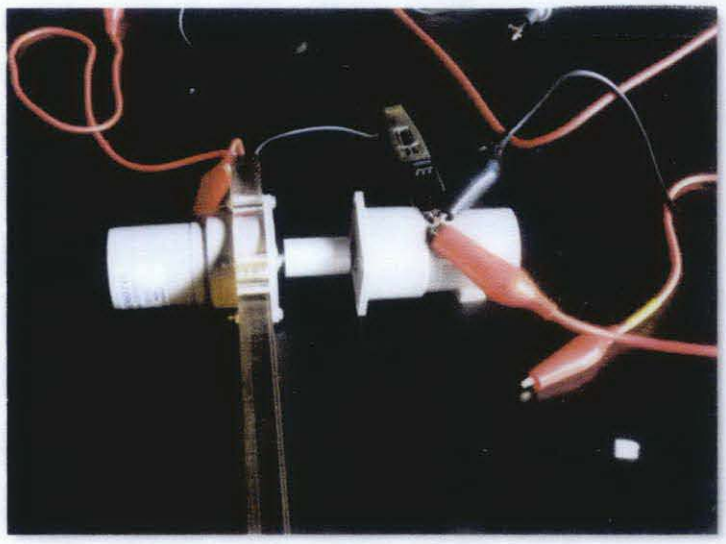


Figure 4.9: Setup for Open circuit test

Figure 4.10: Testing speed for open test circuit

The speed of the motor can be altered by the amount voltage supply. The higher the voltage supply, the higher the speed of the shaft and the greater the mechanical power supply to the generator. As a result, a higher voltage and current are generated.

While voltage is gradually increased and supplied to the motor, the speed of the motor are recorded every 1 volt different. Figure shows the amount of voltage and current generated with different speed of generator. The current and voltage generated are proportional to the speed of the generator. The generator does not move until it reaches 50 rpm in this experiment. It is because the motor need a starting torque to start up the motor. After the motor started, only then supply mechanical power to the generator.

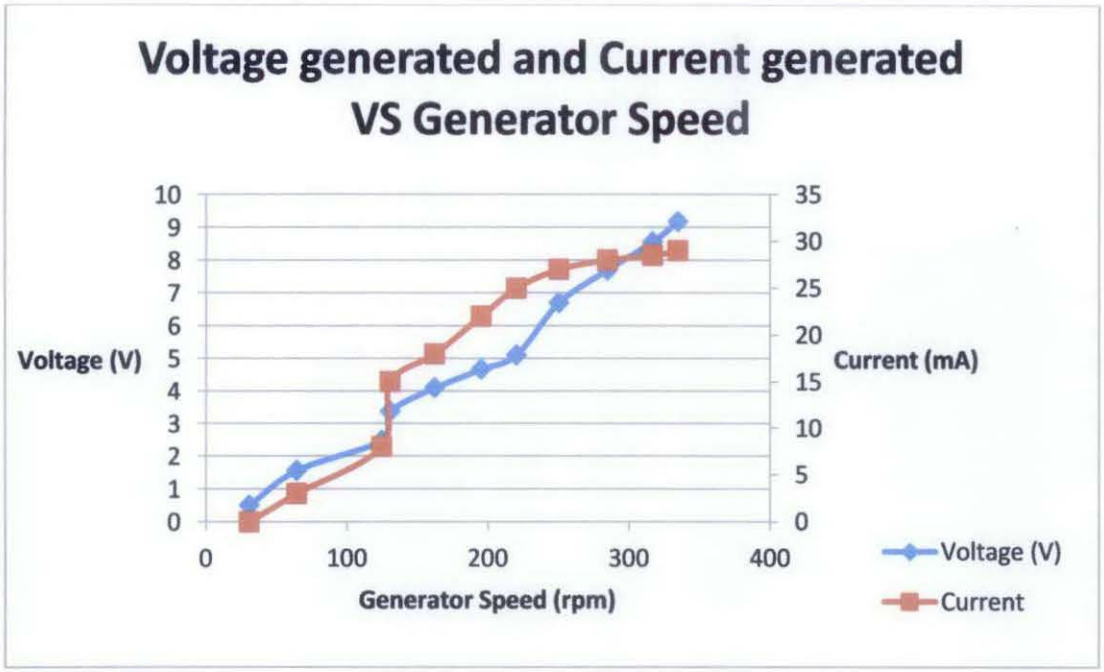


Figure 4.11: Voltage and current generated with the changes of generator speed

4.3.2 External Test

In external test, generator is coupled to the wheel. Throughout the test, water from the water cascade is flowing into the prototype of water wheel. The output voltage and current are tested and the data from the test are recorded. Figure 4.12 shows the external test.

Figure 4.12: Set up for external test

From the test, the flow of the water will manipulate the voltage and current generated. Using the different speed of flow water, the voltage and current generated is recorded.

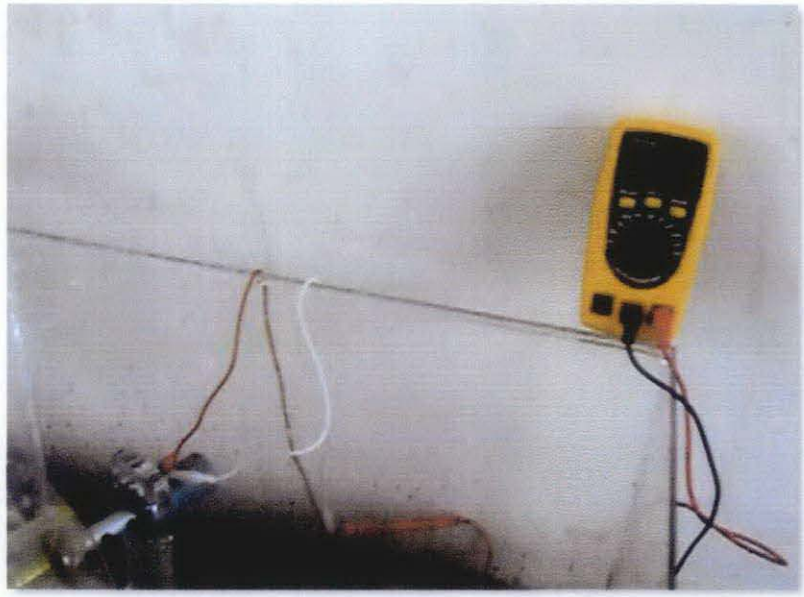


Figure 4.13: Voltage is measured using Multimeter

The voltage generated varied whenever the speed of generator is changing. The changes of speed due to the flow rate of water, the more water flow the higher the voltage and current generated.

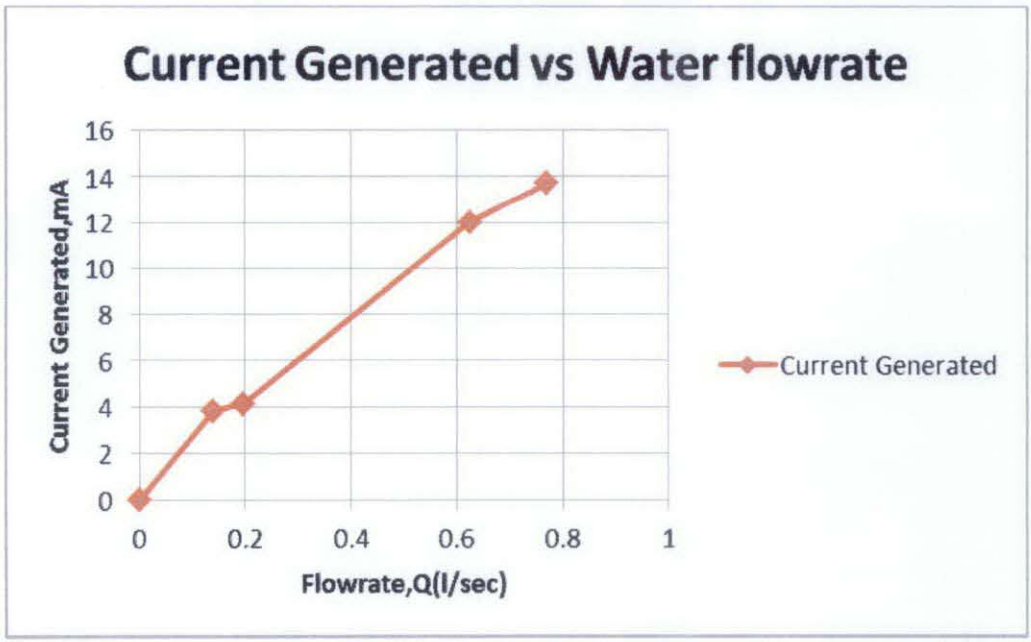


Figure 4.14: Graph of Current generated Vs. Water flow rate

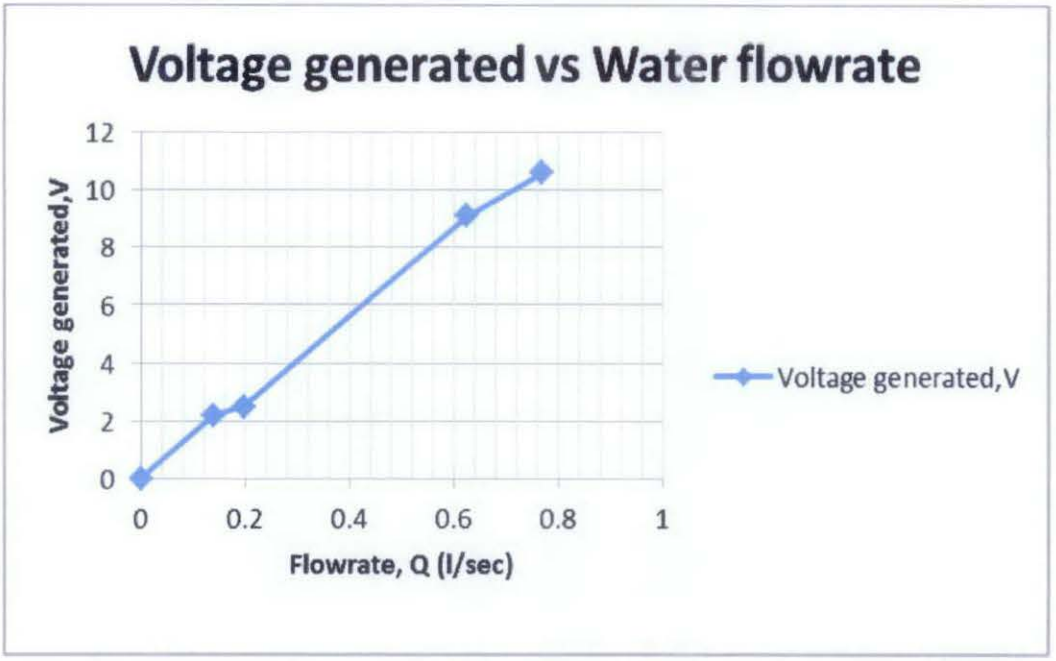


Figure 4.15: Graph of current generated Vs. Water flow rate

4.3.3 Wheel Test

The wheel test is conducted to determine the suitable number of blade for the water wheel. Result from the test has shown that the wheel with higher number of blades will produce higher rotation per minutes. The figure 4.16 shown the setup of the wheel test

Figure 4.16: Setup of wheel test

Turbine	Rotation Per Minutes (rpm)	Flow rate(l/s)
3-Blade	1503 rpm	0.625
6-Blade	2210 rpm	0.625

Table 4.5: Result of design test

4.3.4 Design test

The last experiment conducted in this project is design test. After combining mechanical part and electrical part, the performance of the prototype is evaluated by comparing the voltage and generated current generated. Since the readings are varying throughout the test, hence only the maximum and minimum reading are recorded and listed in the table 4.6.

Figure 4.17: Set up for design test.

Figure 4.18: Measurement of voltage and current generated

Figure 4.19: Model of the UTP mosque is used to display the generated energy.

Result	Maximum	Minimum
Flow rate (liter/second)	0.197	0.14
Voltage generated (V)	2.5	2.2
Current generated (mA)	6.7	4.5

Table 4.6: Result from the design test.

4.4 Battery charger circuit

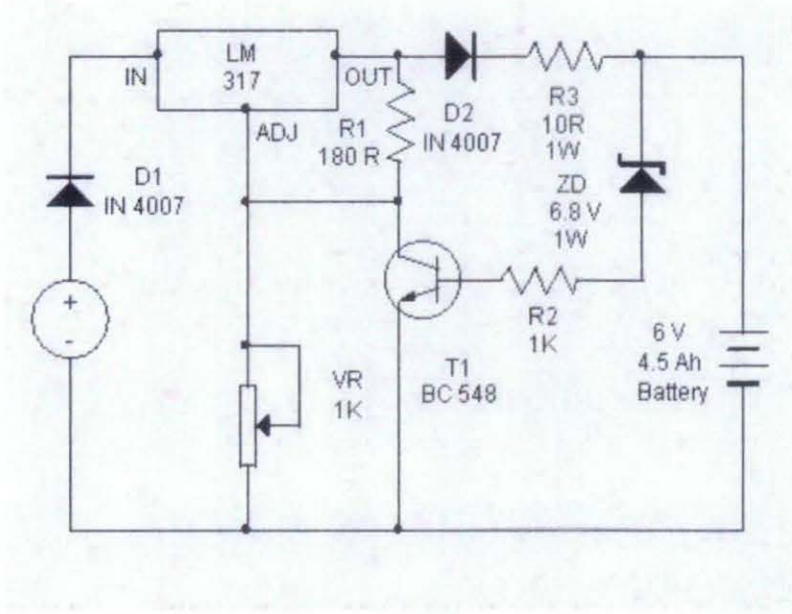


Figure 4.20: 6V battery charger circuit

The circuit uses a 12 volt DC generator output and a variable voltage regulator IC LM 317. Charging current passes through D1 to the voltage regulator IC LM 317. By adjusting its Adjust pin, output voltage and current can be regulated.

VR is placed between the adjust pin and ground to provide an output voltage of 9 volts to the battery. Resistor R3 Restrict the charging current and

diode D2 prevents discharge of current from the battery. Transistor T1 and Zener diode ZD act as a cutoff switch when the battery is full. Normally T1 is off and battery gets charging current.

When the terminal voltage of the battery rises above 6.8 volts, Zener conducts and provides base current to T1. It then turns on grounding the output of LM 317 to stop charging.

The energy stored in the rechargeable battery then will be used to light up the light emitted diode to illustrate the usage of generated power.

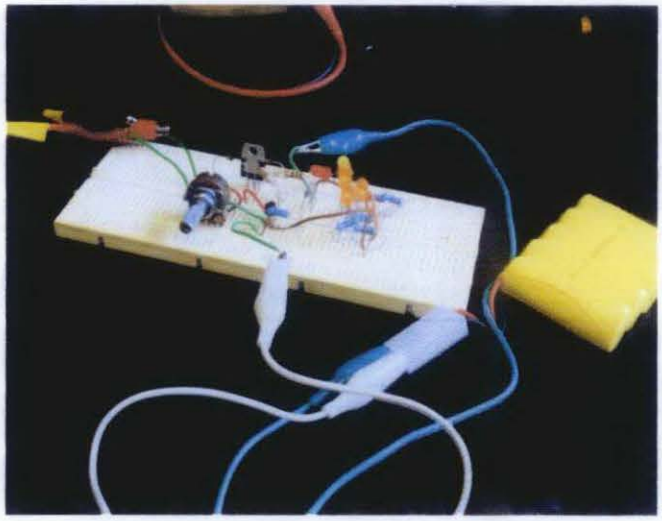


Figure 4.21: Charger circuit on breadboard

4.5 **Expected result of the small scale water wheel generator.**

From data gathering, it found that the UTP water cascade has the width of 50 meter with the height or head of 3 meter. The flow rate measurement test has shown the flow rate of the water is 81 liter per minute or I meter width. Using these data, the hydro-potential energy can be calculated using the following formula:

Power (for 1 meter width) = Head x Flow x Gravity [16]

Where:

- power is measured in Watts,
- head in metres,
- Flow in litres per second, and
- Acceleration due to gravity in metres square (*(The acceleration due to gravity is approximately 9.81 meters per second per second)*

Power = 3 m x 1.36 x 9.81

Power = **40 Watt** (for 1 meter width)

Considering the width of UTP mosque water cascade is 50m, approximately 20 unit of 1 meter water wheel could be installed in summary total of 800 watt can be generated by the water wheels.

Information of UTP water cascade

Height of water cascade (Head) = 3 Meter

Width of water cascade = 50 Meter

Flow rate of water(for 1 meter width) = 1.35 liter/second

Number of (1x1) meter wheel can be installed = 20 units

The potential power can be calculates as follows:

Power = Head x Flow x Gravity Power

= 3 x 1.35 x 9.81

= 40 Watt

Total for 20 units

= 20 x 40 watts

= 800watt

So, the total of power generated per month is:

Power = 800 watt x 12 hours x 30 days

= 288 KW

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In conclusion the purpose of this project is to study the feasibility of water wheel generator at Universiti Teknologi PETRONAS mosque. It has presented the initial idea on building water wheel generator is realistic as the study have shown that the water flow rate at the mosque able to generate some amount of energy. From the calculation the potential energy of the water flow at UTP water cascade able to generate 32 watt of energy. The building of a prototype of micro hydro generator system which consists of water wheel and water cascade also has been completed. From the analysis of the testing of water wheel also prove the capability of the water wheel as hydro energy collector. With the help of circuitry part consist of light emitted diode (LED), this generated power is interpreted.

5.2 Recommendations

The performance of the project is satisfied where it is proved that it is feasible for UTP mosque to have water wheel generator system. Further research could be emphasized for the power consumption of the mosque in order to increase the effectiveness and efficiencies of this model.

For the prototype, the recommendation is to use the water pump with higher output flow as it can use to increase the speed of rotation of water wheel. Another recommendation is to increase the head of the water as it will increase the pressure drop hence increase the rotation of the water wheel.

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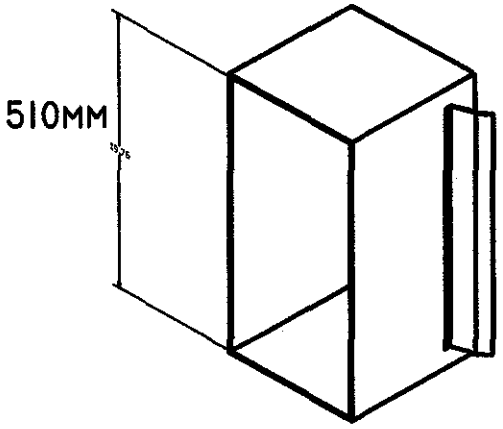
APPENDICES

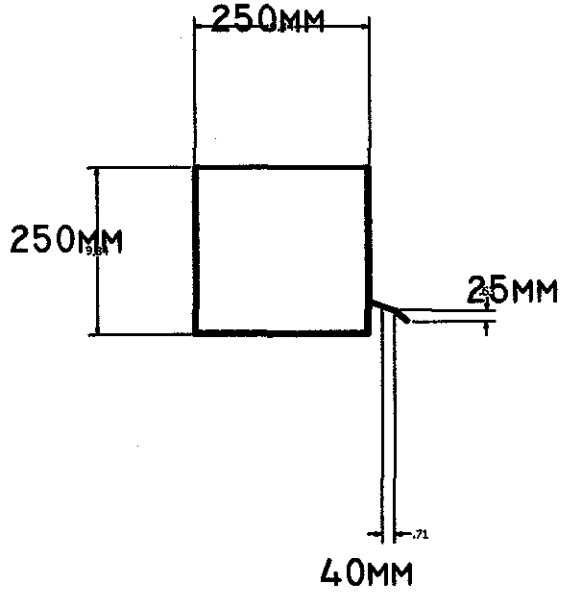
No	Detail\Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Selection of project title															
2	Literature review on motor/generator															
3	Literature review on water wheel/cascading lake															
4	Progress on Proposal work															
5	Autocad/Catia Learning															
6	Submission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

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Fabricate the acrylic container (water cascade tank)														
Construct the electrical circuit and generator selection														
Assembling the water wheel, dc generator and tank														
Experimenting the wheel speed														
Testing dc generator output														
Progress report submission														
Combination of mechanical and circuitry part														
Submission of technical paper														
Submission of dissertation (soft bound)														
Oral presentation														
Project dissertation submission (Hard Bound)														

ISOMETRIC VIEW



RIGHT VIEW



DRAWN Ir.NikHanif	11/22/2011	
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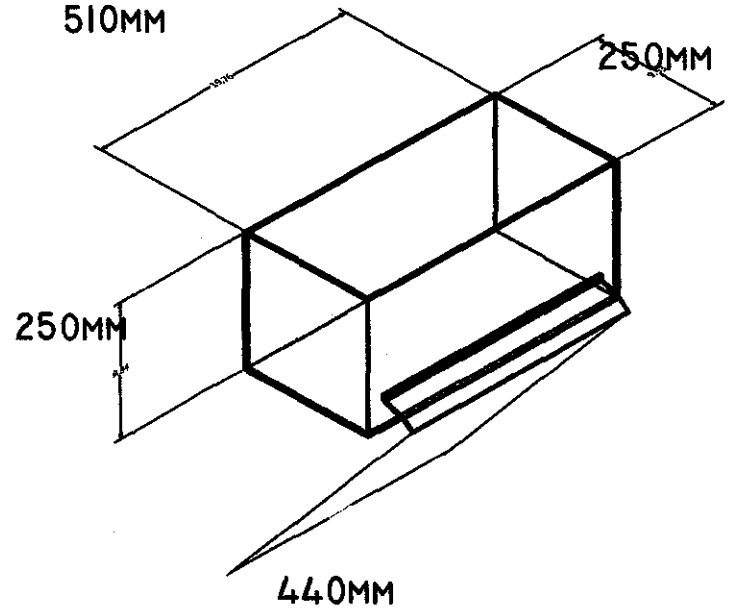
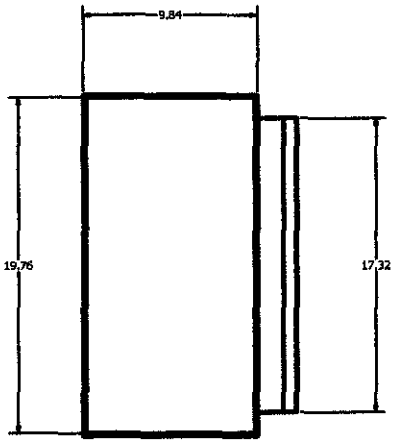
		SIZE C / DWG NO / REV
		SCALE / SHEET 1 OF 1



FRONT VIEW



DRAWN Mr.NikHanif	11/22/2011	
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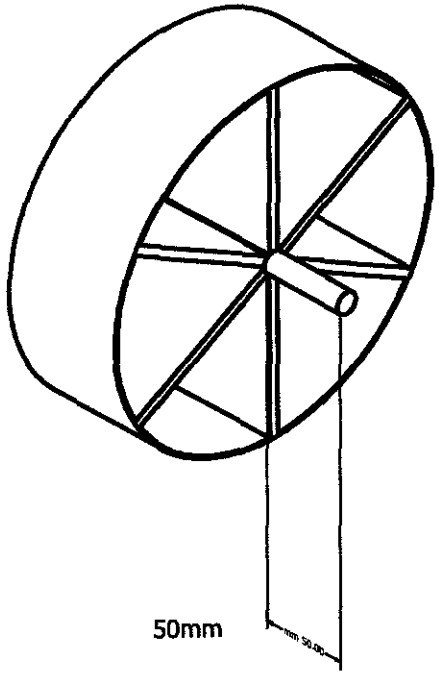
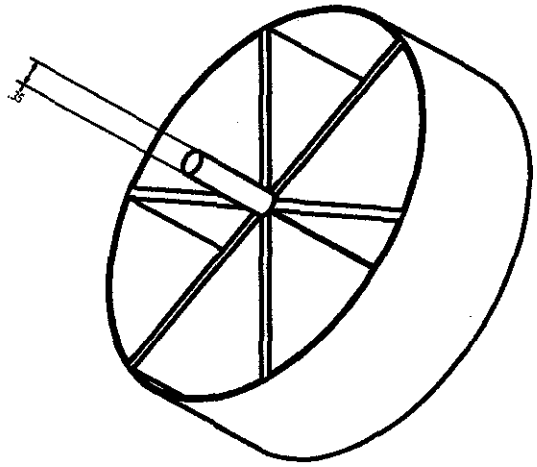
		TITLE
		SIZE C · DWG NO · REV
		SCALE · SHEET 1 OF 1

TRIMETRIC VIEW



35mm



DRAWN Ir Nik Hanif	11/21/2011		
CHECKED		TITLE	
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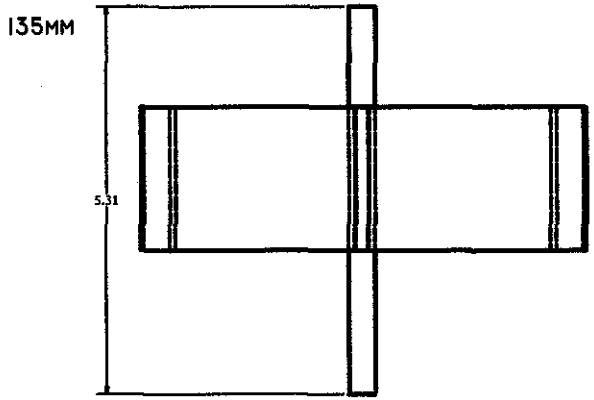
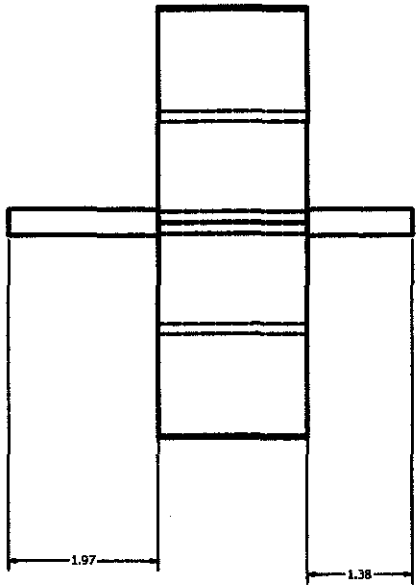
MFG			
APPROVED			
		SIZE C	DWG NO Part1 REV
		SCALE	SHEET 1 OF 1

BACK VIEW



LEFT VIEW



50MM

35MM

DRAWN Ir Nik Hanif	11/21/2011	
CHECKED		TITLE
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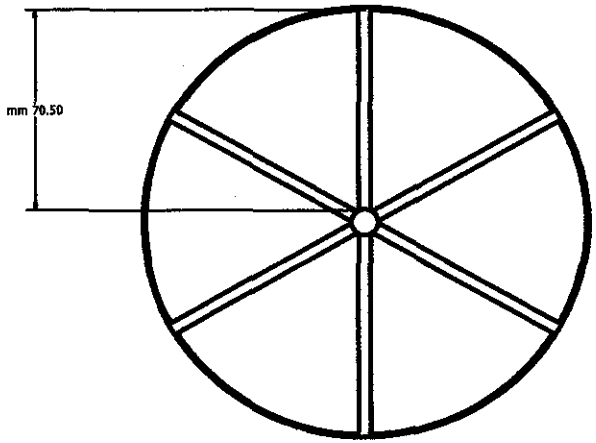
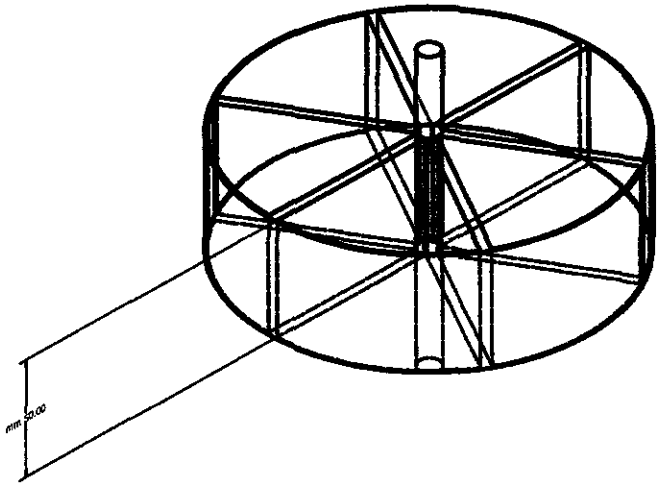
MFG		
APPROVED		
		SIZE C / DWG NO Part1 / REV
		SCALE / SHEET 1 OF 1

Top View





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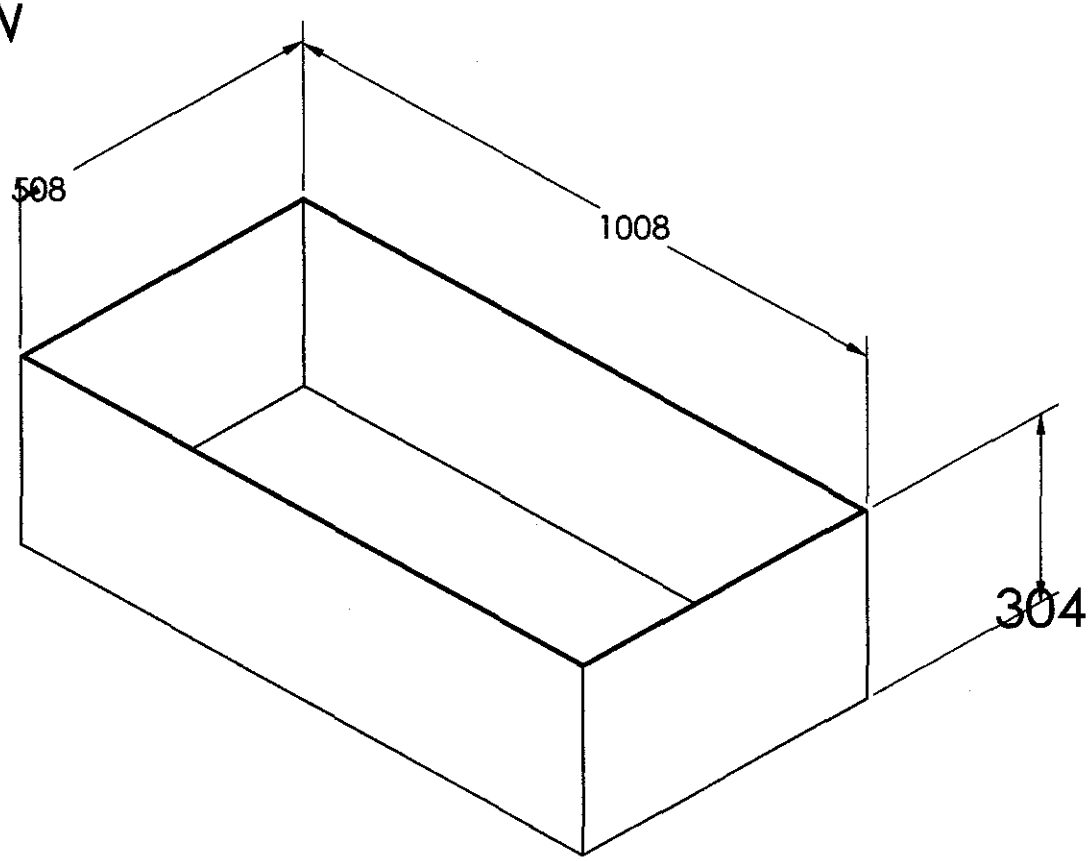
CHECKED		TITLE	
QA			
MFG			
APPROVED			
		SIZE C	DWG NO Part1 REV
		SCALE	SHEET 1 OF 1

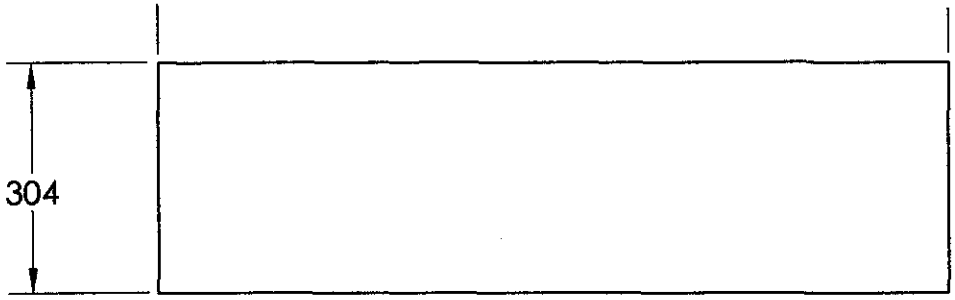
ISOMETRIC VIEW

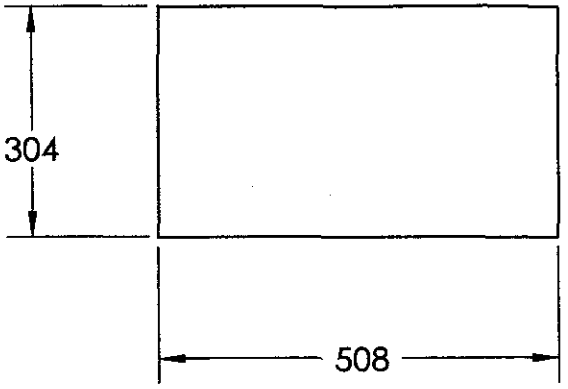


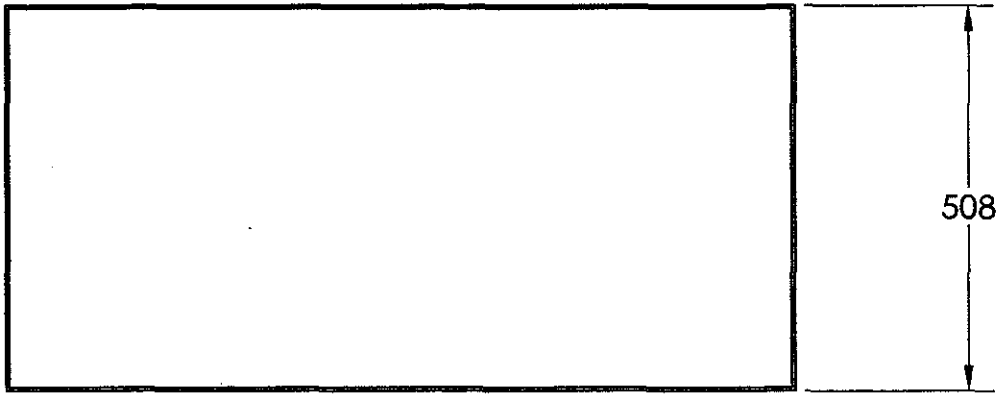
		UNLESS OTHERWISE SPECIFIED:		NAME	DATE
		DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	DRAWN		
			CHECKED		
			ENG APPR.		
			MFG APPR.		
		INTERPRET GEOMETRIC TOLERANCING PER:	Q.A.		
		MATERIAL	COMMENTS:		
NEXT ASSY	USED ON	FINISH			
APPLICATION		DO NOT SCALE DRAWING			

TITLE:

SIZE	DWG. NO.	REV
A	Part9	
SCALE: 1:10	WEIGHT:	SHEET 1 OF 1







NEXT ASSY	USED ON
APPLICATION	

UNLESS OTHERWISE SPECIFIED:	
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ± ANGULAR: MACH ± BEND ± TWO PLACE DECIMAL ± THREE PLACE DECIMAL ±	
INTERPRET GEOMETRIC TOLERANCING PER:	
MATERIAL	
FINISH	
DO NOT SCALE DRAWING	

	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		

COMMENTS:

TITLE:

SIZE	DWG. NO.	REV
A	Part9	
SCALE: 1:10	WEIGHT:	SHEET 1 OF 1

PRODUCT SPECIFICATION FOR DC MOTOR

MODEL: 4 Watt
TYPE: 9904 120 52401---9904 120 52711

1. Type indication

1.1	Spark suppression	Varistor
1.2	Direction of rotation	Reversible
1.3	Rotor	Ironcore
1.4	Nominal data:	See sheet 4&5

2. Electrical data of motor

2.1	Terminal resistance motor 9904 120 524..	3.6	Ω ± 8%
2.2	Terminal resistance motor 9904 120 526..	15.0	Ω ± 8%
2.3	Terminal resistance motor 9904 120 527..	58.0	Ω ± 8%
2.4	EMF at 3000 rpm of motor 9904 120 524..	4.38	V ± 10%
2.5	EMF at 3000 rpm of motor 9904 120 526..	9.40	V ± 10%
2.6	EMF at 3000 rpm of motor 9904 120 527..	18.79	V ± 10%

3. Thermal data

3.1	Temperature coefficient of:		
3.1.1	Motor EMF	-0.2	%/K
3.1.2	Resistance	+0.4	%/K
3.2	Thermal resistances:		
3.2.1	From winding to housing (Rht1)	30	K/W
3.3	Thermal time constant of motor without heatsing	30	min

4. Electromechanical data

4.1	No load	See sheet 4&5
4.2	Starting torque	1 V (max.)
4.3	Loaded	See sheet 4&5
4.4	Typical curves	See sheet 6 to15
4.5	Insulation resistance between winding and housing according to IEC 335-1 (500 VDC)	>2MΩ

75-05-23	Motor assy	9904 120 52401	94-09-28 01-01-04 01-02-19 R.v.Z 01-12-21 R.v.Z
Supers.	Sheet. 190-1		
Name. R.v. Zeelst	Date. 98-06-02		
File 9904 120 52401 190 wnd	Check.		

5. Mechanical data

5.1	Dimensions	See sheet 112-1
5.2	Axial play	0.2 - 0.5 mm
5.3	Wobble of the shaft	-
5.4	Weight	125 g
5.5	Housing	Acetal
5.6	Operation position	All positions permitted
5.7	Brushes	Carbon
5.8	Bearings	Slide
5.9	Connections	Solder tags

6. General specifications
Unless otherwise specified general requirements are specified in reference sheet PN40-01-98

7. Temperatures

7.1	Ambient	-10 to 60	°C
7.2	Storage	-30 to 80	°C

8. Remarks
If not otherwise specified, the measurements have to be done under the following conditions

8.1	Motor temperature	22 ±5 °C
8.2	Atmospheric pressure	860 - 1060 HPa
10.3	Relative humidity	45 - 75 %
10.4	Radial force	None
10.5	Axial force	None

9 Limiting values

9.1 The following maximum values can be applied continuously, however they reduce the life of the motor considerably.

9.1.1	Voltage	1,2	x Vnom.
9.1.2	Load	2	x Loadnom.
9.1.3	Current	2	x Inom.
9.1.4	Speed	1.2	x Nnom.
9.1.5	Output power	3	W
9.1.6	Radial force	See sheet 4&5	
9.1.7	Axial force	See sheet 4&5	

9.2 The following maximum values should never be exceeded

9.2.1	Winding temperature	130	°C

10. Life

10.1 Conditions for life

10.1.1	Voltage	Nominal
10.1.2	Load	Nominal
10.1.3	Radial force	None
10.1.4	Axial force	None
10.1.5	Motor position	Horizontal
10.1.6	Addition of lubricant	Not permitted
10.1.7	Cycle	Continuous

10.2 Life B10 value > 1000 h

10.3 Criteria for approval: Motor function remains intact.
If the *Warning signal* level (see below) is reached in the life test setup, the motor is regular tested for the criteria 10.3.1 to 10.3.3 that prescribe when motor life is finished.

Warning signal: The motor is build out from the life test setup if as warning signal the motor current deviates ± 20% of the initial zero hour value or the audible noise is dramatically increased or if significant interruptions occur in the commutation wave form.

10.3.1	Commutation wave form	No blocked interruptions; Motor should start up in all rotor positions with motor voltage of item 4.2
10.3.2	No load current	2 times the max. no load current of sheets 190-4
10.3.3	Bearings	Bearing function remains intact

nd5