A STUDY ON THE EFFECT OF THE FLOW RATE ON THE POWER PRODUCED BY THE PICO HYDROPOWER

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Thesis submitted in partial fulfillment of the requirements for the award of the degree of
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EXAMINERS APPROVAL DOCUMENT

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I certify that the thesis entitled 'A Study on the Effect of the Flow Rate on the Power Produced by the Pico Hydropower' is written by Wan Mohamad Azam Bin Wan Mahmod with matric number MA09063. I have examined the final copy of this report and in my opinion, it is fully adequate in terms of language standard, and report formatting requirement for the award of the degree of Bachelor in Mechanical Engineering. I herewith recommend that it be accepted in fulfillment of the requirements for the degree of Bachelor Engineering.

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I hereby declare that the work in this report is my own, except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any other Degree and is not concurrently submitted for award of other degree.

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ABSTRACT

This thesis deals with the study on the effect of flow rate on the power generated by the micro hydropower. The objective of this study is to study the relationship of the flow rate end the power generated by the Pico hydropower. The objective of this thesis also is to make the result obtained from the study as a benchmark for the further research on the power generated by the Pico hydropower. The experiment was conducted by using the pump that has the function similarly as the Pelton turbine. The potential energy created by the stream of the water is converted to mechanical energy and the mechanical energy will rotate the blade of the turbine. As the blade of the turbine is rotated, the magnetic field inside the generator been cut and the induction of electric will happen. As the result, the electrical power is produced by the turbine. All the analysis and data collected is done by using Dasy lab software. The obtained result shows that the value of flow rate affect the power generated by the turbine. The value of power generated by the turbine increase as the flow rate increase. The minimum and the maximum value of the power generated also are obtained from the experiment. The result also indicates that difference value of the voltage will generate difference power. The results concluded that the power generated by the turbine is depends on the flow rate because the high flow rate will created enough energy to rotate the blade of the turbine and at the same time the electrical power is produced. The results obtained are very significant to make as a benchmark for the further research on the power generated by the Pico hydropower.

ABSTRAK

Tesis ini berkaitan dengan kajian mengenai kesan kadar aliran kuasa yang dijana oleh kuasa hidro mikro. Objektif kajian ini adalah untuk mengkaji hubungan kadar akhir aliran kuasa yang dijana oleh kuasa hidro Pico ini. Objektif projek ini juga adalah untuk membuat keputusan yang diperolehi daripada kajian ini sebagai penanda aras bagi penyelidikan lanjut mengenai kuasa yang dijana oleh kuasa hidro Pico ini. Eksperimen telah dijalankan dengan menggunakan pam yang mempunyai fungsi yang sama sebagai turbin Pelton itu. Tenaga potensi yang dicipta oleh aliran air ditukarkan kepada tenaga mekanikal dan tenaga mekanikal akan memutarkan bilah turbin. Sebagai bilah turbin diputarkan, medan magnet di dalam penjana itu telah dipotong dan induksi elektrik akan berlaku. Hasilnya, kuasa elektrik dihasilkan oleh turbin. Semua analisis dan data dilakukan dengan menggunakan perisian Dasy Lab. keputusan yang diperolehi menunjukkan bahawa nilai kadar aliran menyentuh kuasa yang dihasilkan oleh turbin. Nilai kuasa yang dijana oleh peningkatan turbin sebagai kenaikan kadar aliran. Minimum dan nilai maksimum kuasa yang dijana juga diperolehi daripada eksperimen. Hasil kajian juga menunjukkan bahawa nilai perbezaan voltan akan menjana kuasa perbezaan. Keputusan membuat kesimpulan bahawa kuasa yang dihasilkan oleh turbin adalah bergantung kepada kadar aliran kerana kadar aliran yang tinggi akan mencipta tenaga yang cukup untuk memutarkan bilah turbin dan pada masa yang sama kuasa elektrik dihasilkan. Keputusan yang diperolehi adalah sangat penting untuk membuat satu tanda aras untuk penyelidikan lanjut mengenai kuasa yang dijana oleh kuasa hidro Pico ini.

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LIST OF SYMBOLS

V	Voltage
D	Diameter of the tube
P	Instantaneous power measured in watts
Q	Volume flow rate
I	The current flow measured in amperes
P	Power of stream of the water measured in watts
g	Gravitational constant
H	Net head
η	Efficiency of the turbine
ρ	Density of the water

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Nowadays the demand of the clean energy increase rapidly with increasing the awareness of the people around the world about the nature has been increased. Recently, the global issues about the nature such as global warming and climate change become the hot issues that is being discussed by the people. To reduce these kind of threat to the nature, the clean energy such as this pico hydropower energy is considered as one of the best ways and suitable to use. The basic concept for this Pico hydropower energy is coming from the words ‘ hydro’ that means the power is earned from the water in small scale. The electrical energy itself is produced according to the principle of conservation of energy that is the energy cannot be created or destroyed and it is can be transferred from one state to another state of energy. It is produced by converting the potential energy that gained from the river water to kinetic energy by using the turbine and it is converted to electrical energy by using the generator.

1.2 PROBLEM STATEMENT

Basically the installation of the Pico hydropower is on the river and waterfall. For instants, the different part of the river has difference flow and at the same time it will generate a difference value of voltage. So, exactly the optimum voltage will be the top one in the priority list. The value of the voltage generated is important since the value of the voltage determines the power generated by the turbine or Pico hydropower . At the same time the value of the flow rate that generates the optimum voltage determines the power produced by the Pico hydropower also should be determined.

Such that the relationship between the flow rate and the power produced can be obtained. For example, how the flow rate affects the power produced by the turbine? and what is the specific value of the power generated at the difference in flow rate, can be the benchmark for the future research. To do this, a study about the relationship of flow rate and the power produced by the pico hydropower should be done.

1.3 OBJECTIVES

There are several main objectives of this study:

(i) To obtain the relationship between the flow rate of the water and the power that will generated by the Pico hydropower.
(ii) To find the specific value of the power that will generated at the certain value of the flow rate of the water.
(iii) To make a benchmark for the future research.

1.4 SCOPE

The scopes of this study is only to determine the value of power produced at difference value of flow rate. Instead of that is to study the relationship of flow rate and the power generated. For this study the pelton turbine is used. All analysis is done by using Dasy lab software.

1.5 THESIS ORGANIZATION

This thesis is organized based on chapter by chapter. This thesis contains five chapters which iare chapter one is for introduction, and chapter two is for literature review, chapter three is for methodology of the study, and chapter four is for result and discussion, and finally chapter five is for conclusions and recommendations.

1.5.1 Chapter 1: Introduction

On this chapter, the brief explanation about the study is being discussed. It is include the problem statement, objectives, and the scopes of this study.

1.5.2 Chapter 2: Literature Review

The objective of this chapter is to deliver of past research effort related to renewable energy, Pico hydropower, history of the Pico hydropower, type of turbine. A review of other relevant research studies is also provided. The review is organized chronologically to offer insight to how past research efforts have laid the groundwork for subsequent studies, including the present research effort. The review is detailed so that the present research effort can be properly tailored to add to the present body of literature as well as to justly the scope and direction of the present research effort.

1.5.3 Chapter 3: Methodology

The methodology had been done right after the motivation and objectives of the project were identified. This chapter functioned as guidance in order to complete the project given. The completed structure of methodology had been illustrated and planned as guideline to achieve the objectives of the project.

1.5.3 Chapter 4: Results & Discussions

The result is obtained after the methododolgy had been done. The purpose of this chapter is to present and discuss the data that is obtained from the experiment. The data is present in the form of table and it is illustrated into graph in order to discuss the data.

1.5.4 Chapter 5: Conclusions & Recommendations

On this chapter the conclusion of this study is being made. The conclusion is basically will answered the obejctives of this study. The recommendations for the furture research also will discussed on this chapter.

CHAPTER 2

LITERATURE REVIEW

2.1 RENEWABLE ENERGY

Renewable energy is some kind of energy that has come from the natural resources such as wind, water, sunlight, rain and geothermal which is naturally can be replenished (Twiddel, J. 2006). This type of energy can reduce the pollutions that occur all around the world. It is also can be the best solution for the global issue such as climate change that is actually happening rapidly nowadays. The climate change happened as a result from the excessive of the greenhouse effect. The gases that such as carbon dioxide, methane and nitrogen oxide acts like a blanket at night to keep the earth warm. These gases trap the heat that is released at night by the earth. However, human activities have changed the concentration of these gases day by day. As a result, excessive of these gases can cause the climate change to occur (Twiddel, J. 2006). So the best way to solve this problem is from the utilization of the renewable energy. The renewable energy is very suitable to apply in the rural areas or the remote areas because it is difficult to get the fuel and the cost is expensive. It can such an alternative way by applying of the renewable energy there (Twiddel, J. 2006). There are several main forms of renewable enrgy such as wind energy, hydropower energy,biomass energy, ocean energy and geothermal energy.

2.1.1 Wind Energy

Wind is actually the air in motion. It is actually has the horizontal motion only. It is cannot been seen by the naked eyes, but the present ot the wind can be measure by the force that it applies on the objects (Shahrani. 2011). For an instant, the motion of leaves the tree on a windy day.

It is found that wind is originate from solar energy. It is form from the result of sun heating the earth, the uneven of the earth's surface , and rotation of the earth (Shahrani. 2011). The pattern of the wind flow is actually is determined by the earth's terrain,bodies of water, and vegetative cover. When the modern wind turbine is applied on this flow, so the electricity can be generate. There are several factors that will affect the formation of air such as mountains, trees, and building. These kinds of factor sometimes will turn into obstacle.

There are pros and cons for this wind energy. The advantages for the wind energy is wind is free, renewed and non- taxable. Moreover, when tihis ind nergy is utilize there is no generation produces pollution in the future. Instead it is cheaper compare to another energy situation. The disadvantages of this wind energy is turbines only work in breezy areas. It is also needs high cost to install at the intial. It is also provides longger payback period which is in 5 to 10 years.

2.1.2 Geothermal Energy

This energy is actually originate from the heat hat is originally from the inside of the earth. It is create a source of renewable heat or renewable electricity. There are several types of resources. For the current commercial utilization,the types of resources are hydrothermal resrvoirs and earthenergy.hot, hot dry rock, geopressed brines, and magma are the advanced technologies yet to be developed (Shahrani. 2011).

Hydrothermal eservoirs are large pools of steam or hot water trapped in porous rock. The steam or hot water will drives a turbine that spins an electric generator as it is pumped to the surface of the earth (Shahrani. 2011). While earth energy is direct used, which is using the heat directly from the water to heat the building, resorts or agriculture purpose.

2.1.3 Biomass Energy

Biomass is another types of renewable energy. It is originate from the carbonaceous material or residue from animals nd plats (Shahrani. 2011). The example of residue such as waste from animal, agriculture and forestry. This kind of energy does ot increase the composition of the carbon dioxide in atmosphere because it absorbs the same amount of carbon in growing the pants as it releases when consumed as fuel (Shahrani. 2011). The process actually create the material cycle.

Biomass resources can be classify into several types such as energy crops, organic, and vegetable (Shahrani. 2011). Energy crop is such as farm that cultivate fast growing platns that will supply biomass energy from its residue. Instead vegetable resources is natural growth. Organic waste and residue resources such as, forest residue, agriculture residue, urban residue, animal waste and industrial waste (Shahrani. 2011).

2.1.4 Ocean Energy

Ocean is actually has high potential to create renewable energy. This because the ocean cover 70% of the earth (Shahrani. 2011). Actually this energy is at the early stage to expand the renewable energy and it is still new. There are three types of conversion fro his energy such as tidal energy conversion, wave energy conversion, and ocean thermal energy conversion (OTEC).

Tidal energy conversion is caused from the natural phenomena. It is caused by the combined attraction of sun and moon on the waters of the revolving globe (Shahrani. 2011). It will cause low tides and high tides. This will happened twice per day.

Wave energy conversion is the motion of water up nd down.this movement in large quantities can produces and generate electricity or mechanical power.

OTEC energy conversion is the conversion of thermal energy which is come from the temperature difference between the surface of the water and the deep water (Shahrani. 2011). The surface of the water has higher temperature compared to the deep water as the sun radiates the surface of the water directly. The temperature is decrease as depth of water increase. This process similar to the conversion of steam power plant.

2.2 HYDROPOWER

From basic understanding, the words hydropower is defined as the power that will obtain or generated from the water. However, the words cannot define the exact characteristic of one thing. They should be more specific to define something. According to (Abbasi T, 2010), there no specific term to define the small hydro yet. So the author just defines the small hydro by hydroelectric power station or plant that can generate the electricity up to 25 MW. Moreover the small hydro can be categorized into Pico, pico and small. This statement can be proved when (Energy, 2010) stated that the hydropower can be define by its capacity. It is found that the hydroelectric can be categorized into pico, mini and small hydropower. The author said that the pico can goes up to 100 KW, mini can goes up to 1MW and small is above 1MW up to 25MW. Table 2.1 will show the classification of the hydropower that being done.

Table 2.1: Classification of hydropower generation

Hydro generator	**Capacity**	**Feeding**
Large	More than 100 MW	National power grid
Small	Up to 25 MW	National power grid
Mini	Below 1 MW	Pico power grid
Pico	Between 6 and 100 KW	Small community or remote industrial areas
Pico	Up to 5 KW	Domestic and small commercial loads

Source: (A.M.A. Haidar, 2012)

2.2.1 A Brief History

Hydropower is just one type of renewable energy that is very familiar. These kind of renewable energy actually had known for a long time ago (Abbasi T, 2010). It is found that almost the two decades this type of renewable energy had known and it’s not just something new. It is found also that hydropower is the technologies that being used by human since centuries. This has being agreed by (Bakis R, 2007). Hydropower is one of the oldest methods that have been used by the human to produce mechanical energy instead of electrical energy because the generation of the hydroelectricity began only from the 19th century (Bakis R, 2007). It is found that in the 19th century the water turbine has been used widely in industry in order to produce electricity (A.M.A. Haidar, 2012). But a long time ago water-mill was used instead of turbine. Moreover watermills hydropower is used long time ago all around the world (Abbasi T, 2010). Instead of that watermills have been used since 900 years ago in the uk. As stated by The Schumacher Centre for Technology and Development, there were 20, 0000 water mills that are functioning in England. It is also being found that the water turbine actually has being created in France in 1827 and the new era of modern pico hydropower was begin (Abbasi T, 2010). The use of waterwheel is fully replaced by the using water turbine at the end of 19^{th} century (Abbasi T & Abbasi SA, 2010). The first invention of hydroelectric system based on waterwheel is started at the Wisconsin, USA in 1882. It was also being stated that in Fox River, some area in Wisconsin, there is the first moving wheel which is being used to generate electricity and it is trusted to be the first one in USA (A.M.A. Haidar, 2012).

2.3 TURBINE

Turbine is the main part of pico hydropower system, turbine will convert the energy from falling water into rotating shaft power and then it will generate the electricity. (A.M.A. Haidar, 2012). In fact energy from falling water can be converted by the turbine into rotating shaft (Paish O, 2002). It is also found that in order to choose the suitable turbine the condition and specification for the site is very important. The turbine can be classified into high-head, medium-head, or low-head (Paish O, 2002) as shown in table 2.2.

Table 2.2: Impulse and reaction turbines

Turbine type	**Head classification**		
	High (>50m)	Medium (10-50 m)	Low (<10 m)
Impulse	Pelton Turgo Multi-jet pelton	Crossflow Turgo Multi-jet pelton	Crossflow
Reaction		Francis (spiral case)	Francis (open-flume) Propeller Kaplan

Source: (Paish O, 2002)

There are two types of turbines which are impulse and reaction turbine. The turbines also can be group into two depending on how it operates. There are two group of turbine which are impulse turbine and reaction turbine (Paish O, 2002). The reaction turbine is actually immersed in the water and it will fully operate in the water. While the impulse turbine its runner operates in air, driven by a jet (or jets) of water, and the water remains at atmospheric pressure before and after making contact with the runner blades. The Pelton, the Turgo and the Crossflow are the impulse turbine while the Francis and the Francis is the reaction turbine. The figure 2.1 show the first type of impulse turbine which is Pelton turbine.

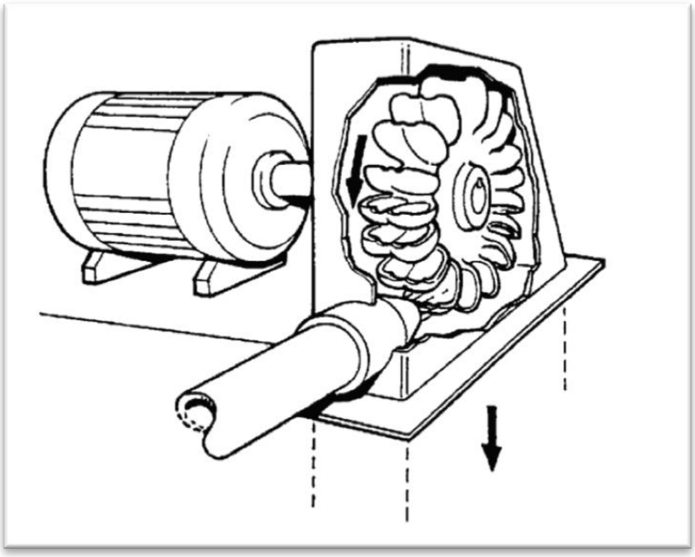

Figure 2.1: Pelton turbine

Source: (Paish O, 2002)

The Pelton turbine is the most commonly used in the pico hydropower system according to it efficiency and this type of the turbine is actually can operate at the very low flow rate and can generate the electric easily. This type of the turbine can be group into the impulse turbine. This type of turbine cannot operate in the free flow of water and instead the Pelton turbine needs nozzle to drive the water and to create a high speed- jet (Johnson, V. 2008). This jet is hit the bucket from the Pelton turbine, and from that the potential energy that gained is convert into kinetic energy, and finally the kinetic energy or mechanical energy will turn into electrical energy. This concept is came from the principal of conservation of energy which is the energy cannot be create or destroy but it can be transfer from one form to another form. The advantage of this turbine is it required low flow rate to generate the power. The maintenance for this turbine also can be done easily since the part of the turbine components is can be separate. It is easier to do the maintenance.The Pelton turbine requires the high value of head pressure to produce power. It is found that this kind of turbine needs high value of pressure head which is larger than 60 (Johnson, V. 2008).

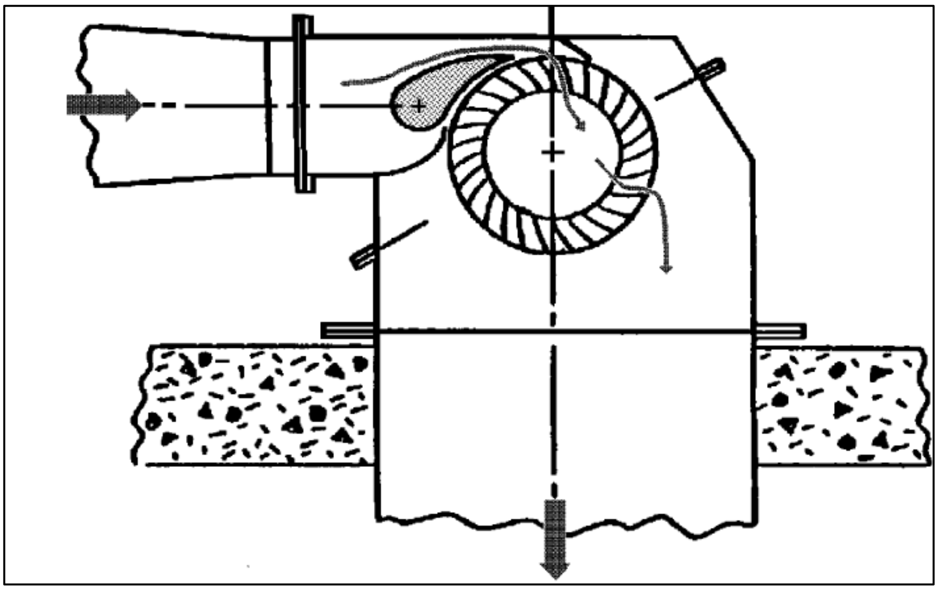

Figure 2.2: Crossflow turbine

Source: (Paish O, 2002)

Figure 2.2 shows Banki-Mitchell turbine or crossflow turbine. This turbine also came from the same group with Pelton turbine which is from the impulse turbine. Even though it was categorized under same group with the Pelton turbine, the Banki-Mitchell operates differently from the Pelton turbine. Unlike the Pelton turbine, the Banki-Mitchell use a cross flow water to produced power. The water stream travels to the turbine transversely or across the turbine blades. Same as another type of turbine, this turbine also has its own advantages and disadvantages. It is found that this type of turbine can function in high range of head height which is between 5-200 m (Johnson,

V. 2008). Moreover the design of this turbine also is very simple and it is no require a high cost to fabricate. Instead of that this turbine also is easy to repair. This turbine also has the high acceptance of the flow variation and it also can be function at the difference period. The Banki-Mitchell turbine also has the disadvantages such as the turbine has the design that is not very safety. It has the blades which are very sharp and this is make the design unsafe.

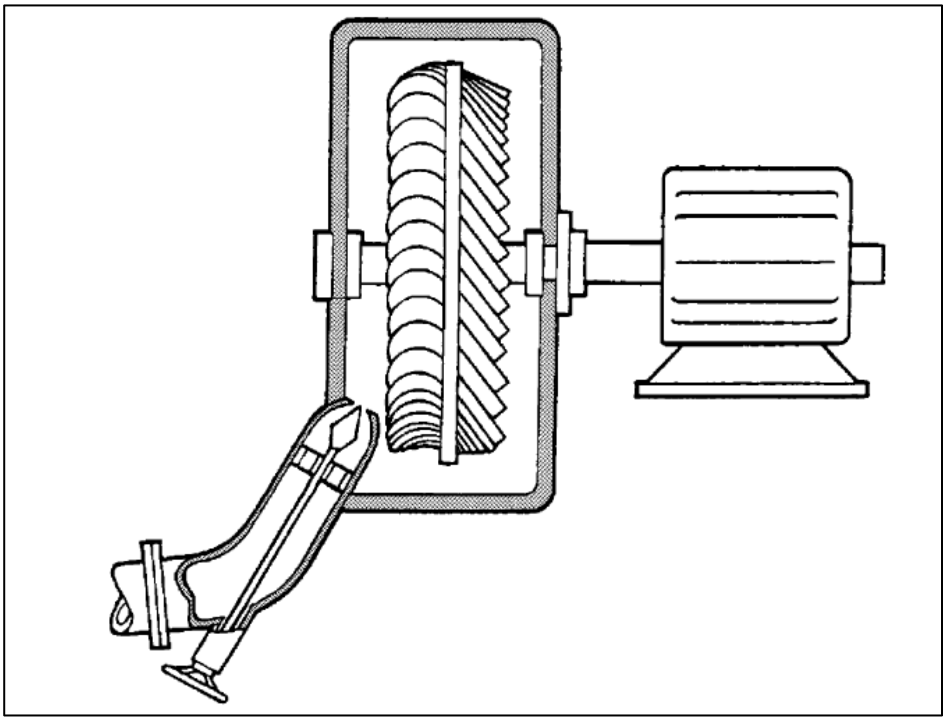

Figure 2.3: Turgo turbine

Source: (Paish O, 2002)

Figure 2.3 is shown the Turgo turbine. Turgo turbine also can be categorized under the impulse turbine group same as form the previous turbine that has been discussed. A high speed jet of water is applied to the blades of the turbine which then deflects and reverses the flow. This impulse causes the turbine runner to spin, passing energy to the shaft of the turbine. The advantage of this turbine is it is not expensive to fabricate and also have high acceptance of the stream variation. And it is also not required to be wrapped.

Next is the reaction turbine. The examples of the reaction turbine are Kaplan and Francis turbine. It is found that, the Francis turbine operates by the water entering the turbine centrifugally by spiral case and the water going out axially (Johnson, V. 2008). The Francis turbine has 4 flexible guide vanes before the runner to accommodate a range of water flow conditions and can be oriented upright or parallel. This turbine also has high efficiency compare to the other turbine. Instead of that, this turbine requires a large range of head height which is 25-350 m (Johnson, V. 2008). It is also being found that this turbine has medium acceptance of flow. But this turbine is not suitable for small hydroelectric. This turbine only suitable for the large hydropower. And it is also must be fully put in the water and it must be covered by using the pressure casing. This specification made the turbine is very difficult to repair. Figure 2.4 shows the Francis turbine.

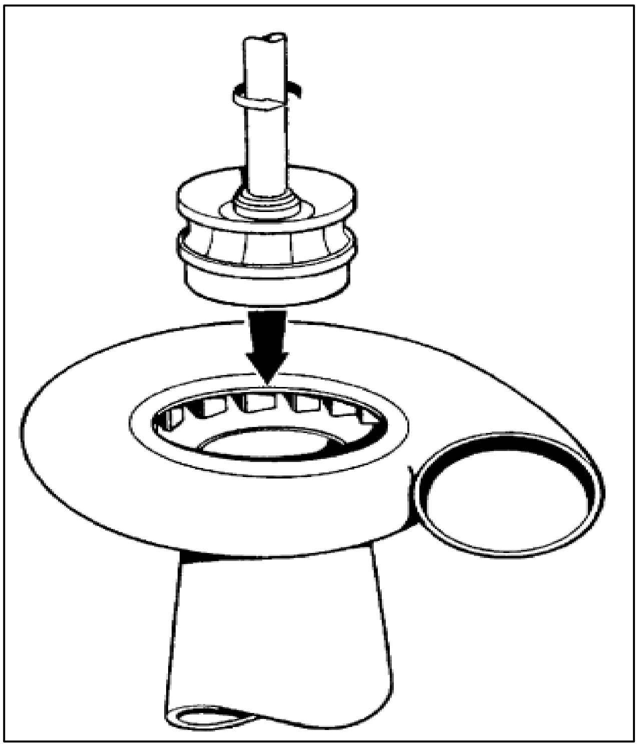

Figure 2.4: Francis turbine

Source: (Paish O, 2002)

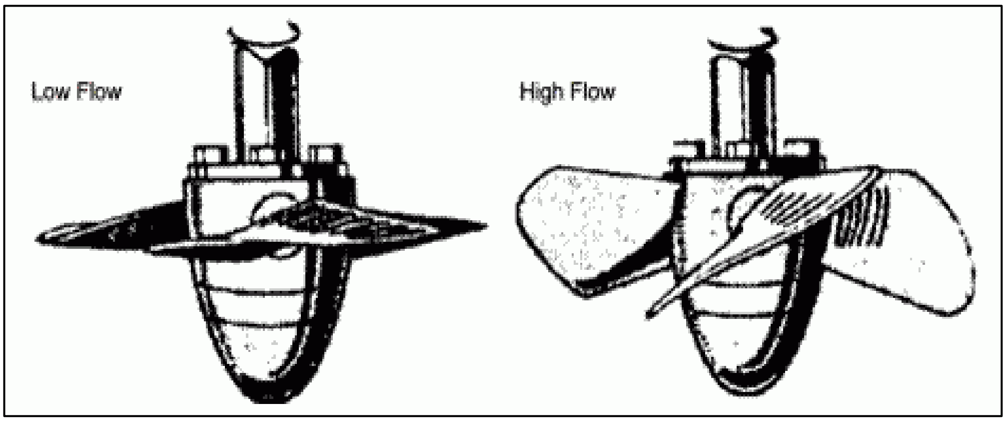

Figure 2.5: Kaplan turbine

Source: www.renewablesfirst.co.uk

Figure 2.5 shows another type of reaction turbine which is Kaplan turbine. This turbine also based on axial flow and it is usually can be operate in low head. The special specifications of this turbine is it has flexible runner blades or it is also has flexible guide- vanes. It is called double regulated Kaplan turbine if it has both of the mentioned specifications otherwise it is called single regulated Kaplan turbine if it has just one of that specifications. Because of it ability to operate at the low head, by using of this turbine the cost of penstock can be reduce. But this turbine require high flow rate to generate the power. In the meantime it also needs high potential energy to move the blades. This turbine also same with the Francis turbine because it needs to be fully immersed in the water and this condition make the turbine hard to repair. As addition, according to the requirement of this turbine to operate at the high flow rate, this turbine needs high cost to fabricate and manufacture the blades. This also needs high cost for installation.

CHAPTER 3

METHODOLOGY

3.1 HIERARCHY OF THE WHOLE PROJECT (PICO HYDROPOWER)

The figure 3.1 below shows the hierarchy of the whole project for the pico hydropower. This study or this project is under the Control & Regulation system which is monitoring system (voltage, power, & flow rate). There are also others group in this whole project such as flume fabrication group and turbine design group. Under flume fabrication group there are two subgroups which are only focused on the study of water flow control system, and on the study of river monitoring system.

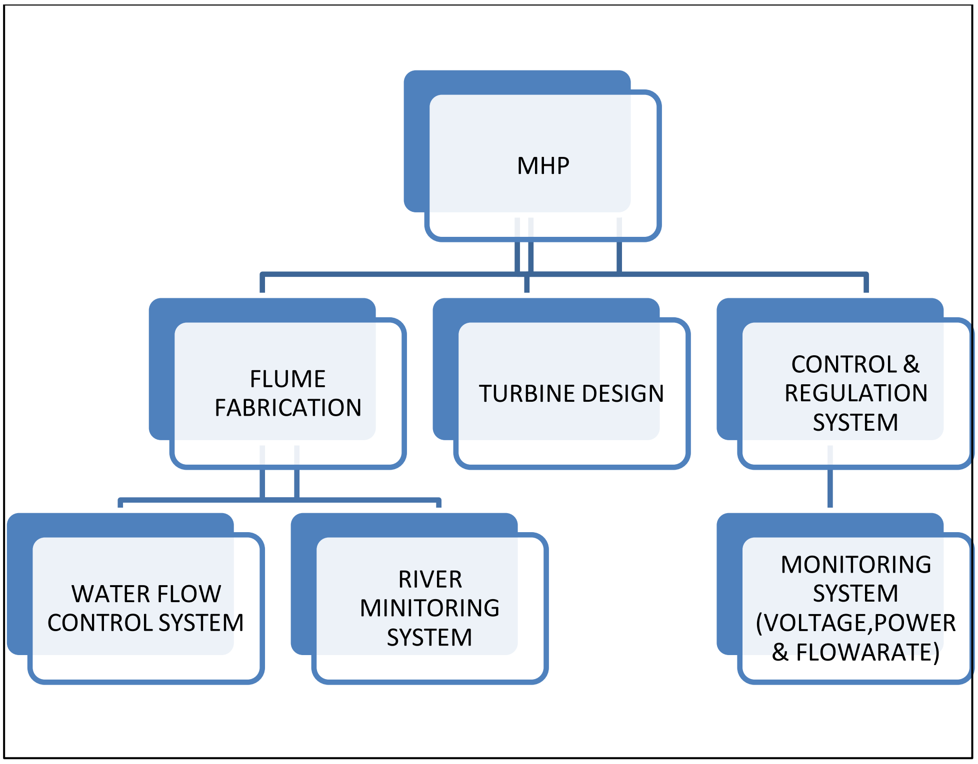

Figure 3.1: Hierarchy of the whole project

3.2 FLOW CHART OF THE METHODOLOGY

The flow chart of methodology is designed purposely to achieve the project's objectives. Figure 3.2 shows the flow chart of this project. This final year project was based on the flow chart so that it will always work in the right flow. From the start, it was about study and gathering all the information that related to study the effect of the flow rate on the power produced by the pico hydropower. This project starts with literature review and research from finding books and journals related to the title as a reference to study. From all of the reading, the understanding about the main objective will increase. And from literature review it is enough to show how the flow or how to conduct the project. First of all, the type of equipment or apparatus that going to use while experiment was conducted is determined. Then the hardware or driver is identified. Before run the experiment, the worksheet of block diagram is created. This block diagram is used to visualize and to get the data from the experiment. The block diagram is created in the Dasy lab software. This will discussed more the subchapter 3.5. And then the experiment is run. The data that have been collected from the experiment is been analysed by using Dasy lab. If there any mistake or problems from the data, modification is made and the step is return to run experiment again and if no modification that are going to make the step can proceed analysed the data and the conclusion finally can be made from the result obtain. Study will finish with documentation and presentation. During these work progress, thesis writing had be done until the presentation that present the progress of whole work

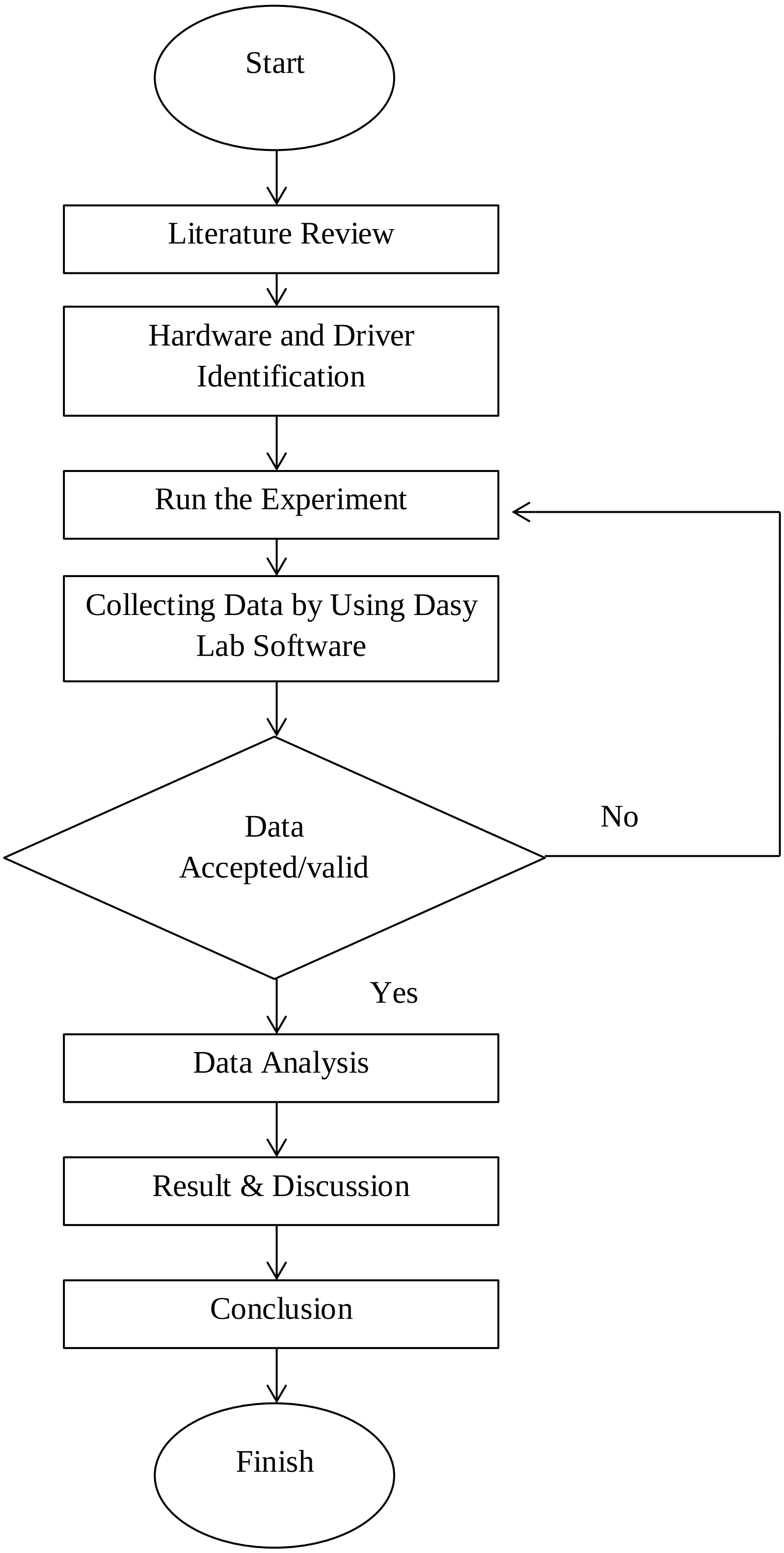

Figure 3.2: Flow chart

3.3 THE EQUIPMENTS REQUIRED

There are several equipment that are required to conduct this experiment. All of this equipment is important to conduct this experiment. The examples of equipments that being used in this experiment such as pump, water tube, tank, multimeter, and data acquisition.

3.3.1 Pump

Pump is used as the turbine for this experiment. This pump is function as the turbine in this experiment. This pump can operate same with the pelton turbine because this pump also have the blade that is same shape with pelton turbine. This pump also need a path that will drive the water to hit the blade of the pump and the potential energy from the water is converted to kinetic energy and finally the generator inside the pump will convert the kinetic energy into electrical energy by using the concept of induction of electricity. The specifications of this pump is it will produce maximum volatge of 12 V and the current is 1.05 A. Figure 3.3 shows the pump and its specifications.

Figure 3.3: Pump as the turbine

Figure 3.4 and 3.5 show the technical drawing of this pump and figure 3.6 shows the blade of this pump.

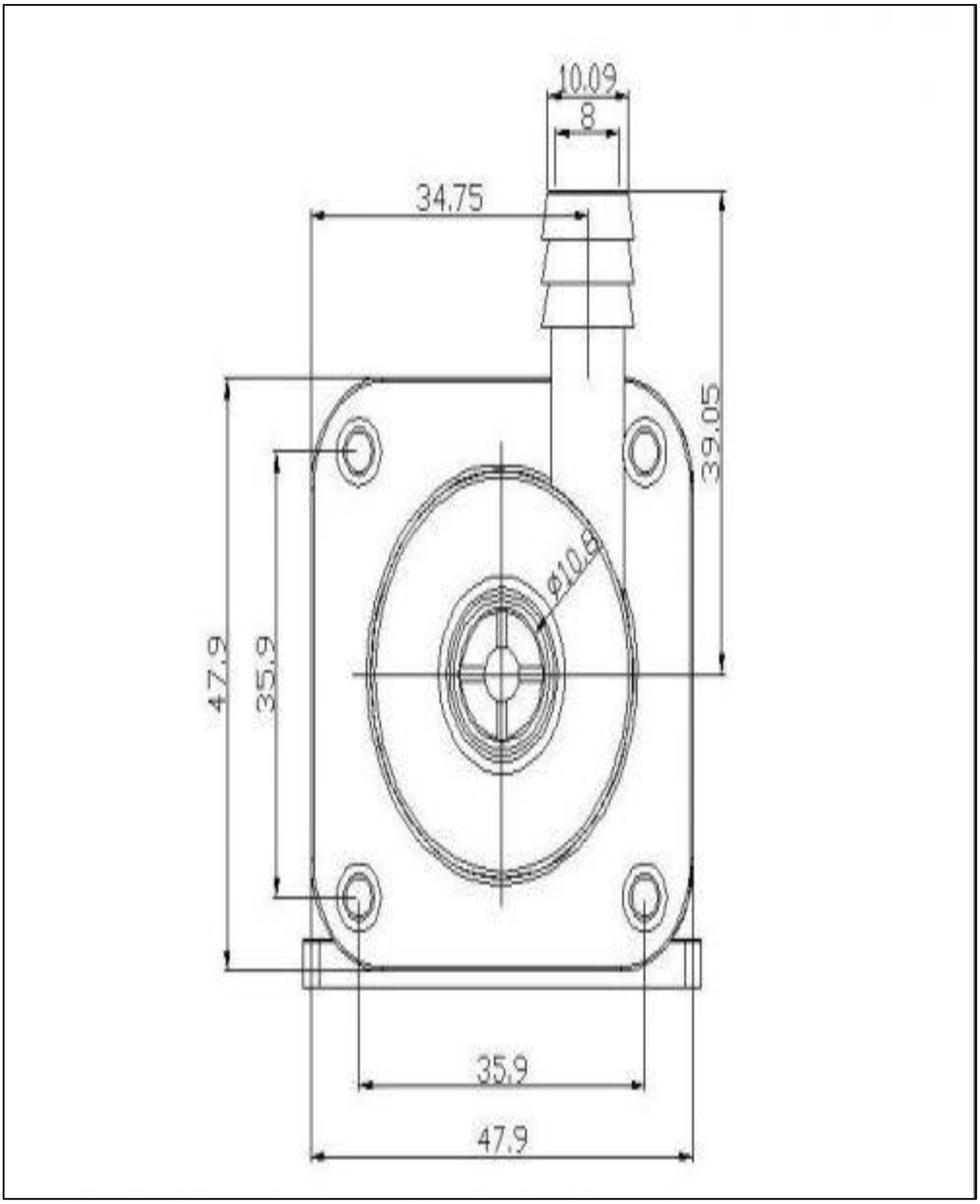

Figure 3.4 : Technical drawing (front view)

Source: www.fystore.com

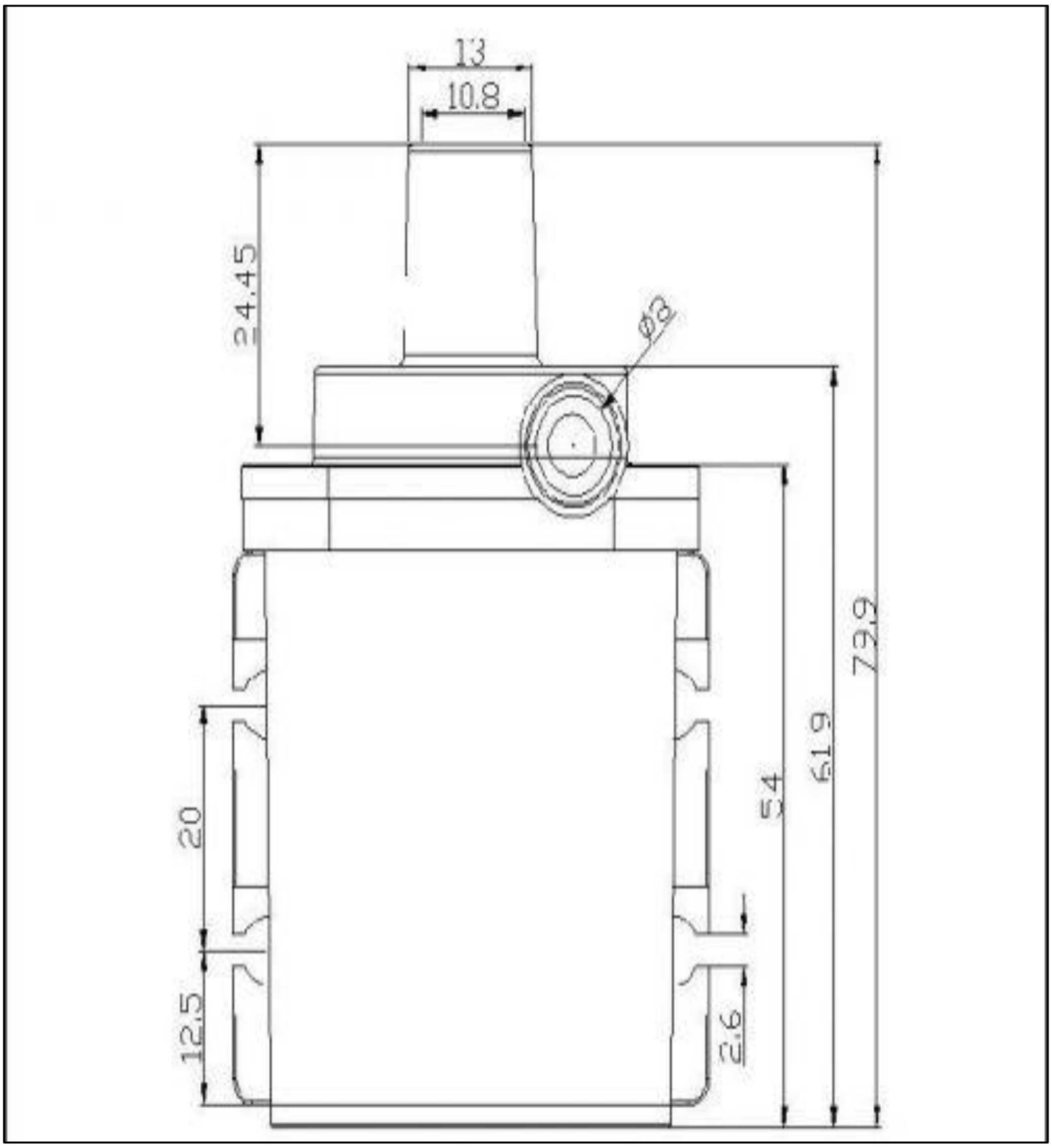

Figure 3.5: Technical drawing (side view)

Source: www.fystore.com

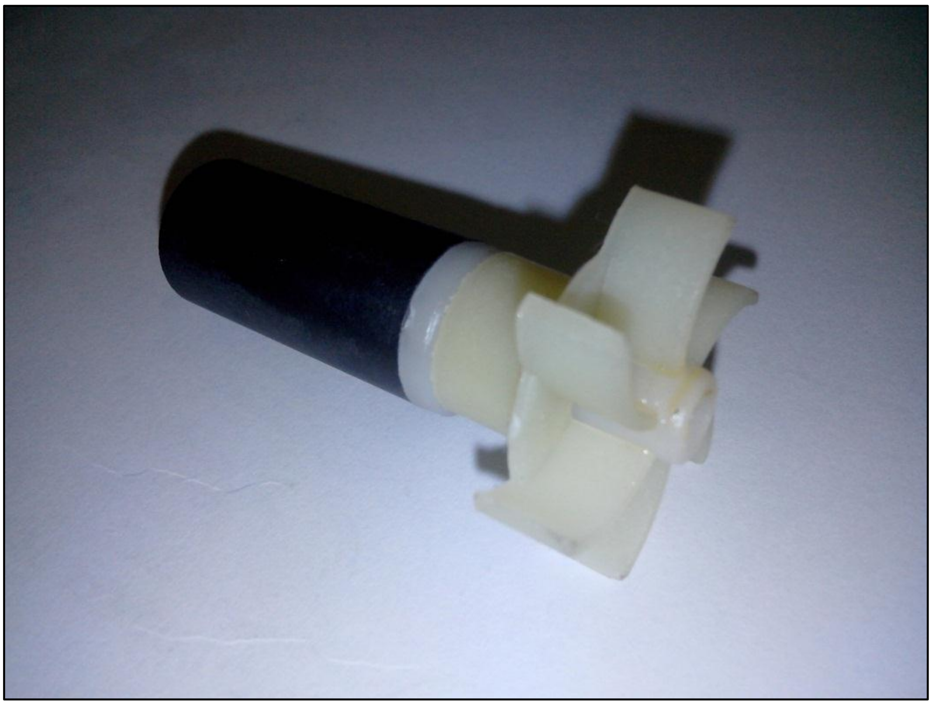

Figure 3.6: Blade

The blade is connected to the shaft. There is a stator magnet attached to the shaft of this pump. As the water hit the blade of this pump, it will rotate and at the same time the magnet at the shaft of this pump also will rotate. From this rotation the electrical energy is produced as the magnetic field is cut. At the first water hit the blade, the potential energy from the water is converted to kinetic energy and finally the generator inside the pump will convert the kinetic energy into electrical energy by using the concept of induction energy. Figure 3.7 show the generator of this pump.

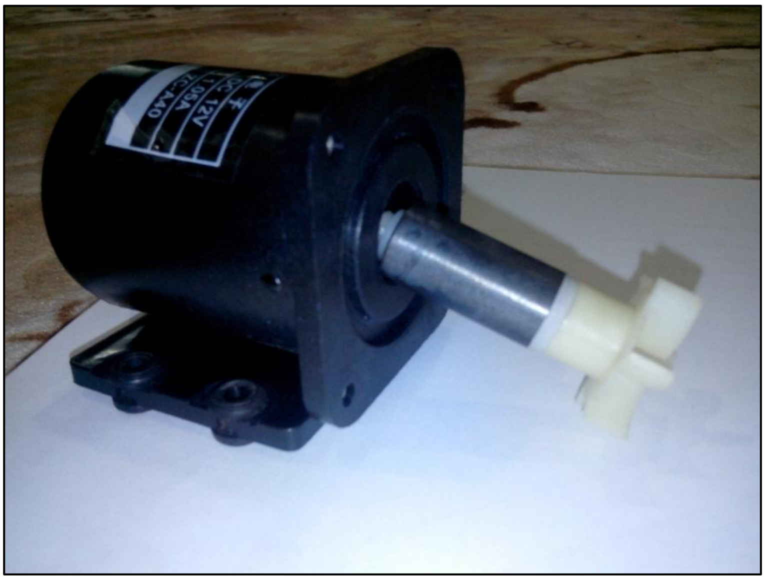

Figure 3.7: Generator

3.3.2 Water Tube

Water tube is used to connect the pump to the water supply. The size of this water tube is 12mm. This is according to the inlet size of the pump which is also 12mm. the same size is used because the water tube is connected to the inlet of the pump. Figure 3.8 shows the water tube.

Figure 3.8: Water tube

3.3.3 Tank

Figure 3.9 shows that the tank that is used for this experiment. The size of this tank 1m × 1m × 1m. The volume of this tank is $1m^3$. Instead of using the smaller tank, this tank is used as the reservoir to collect the water while this experiment is conducted because the amount of the water flow out from the pump is unexpected. This is to prevent the water overflow from the tank. So this is the reason why the bigger tank is used for this experiment.

Figure 3.9: Tank

3.3.4 Multimeter

Multimeter is been used to detect the voltage produced by the turbine manually while doing the calibration of flow rate and the velocity of the water. The figure 3.10 has shown the multimeter that has been used.

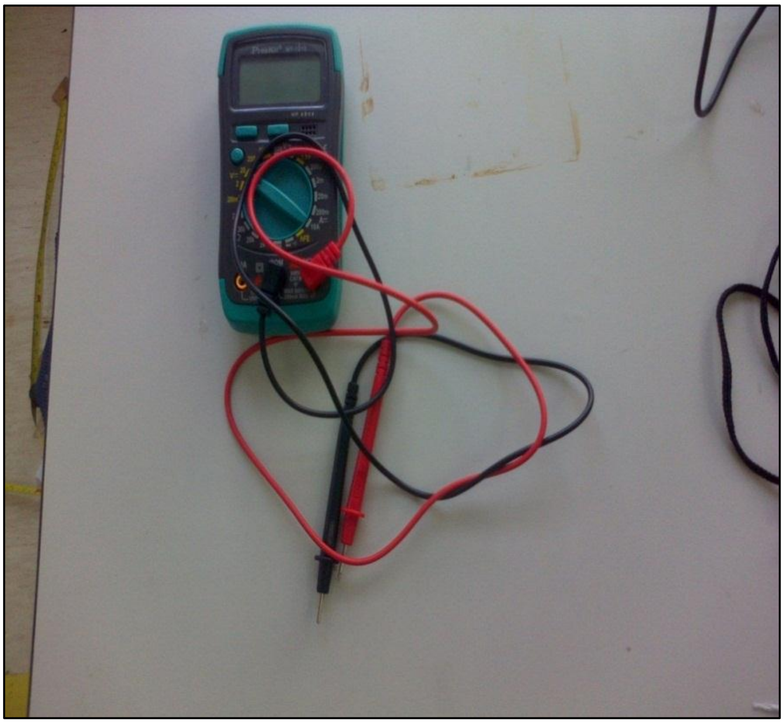

Figure 3.10: Multimeter

3.3.5 Stopwatch

Stopwatch also has been used in this experiment to record the time of water to rise at 1 litre level of beaker. This purpose of using this stopwatch is also for calibration of the flow rate and velocity. The figure 3.11 shows the stopwatch that has been used while this experiment was conducted

Figure 3.11: Stopwatch

3.3.6 National Instrument (Data Acquisition)

For this project, the national instrument is required as interface for the control system. The interfaces that are going to be used are A/D converter NI 9239 and . And the chassis are NICDAQ9174. The NI 9239 and afford a USB interface for four channels of 24-bit instantaneous analog input with integrated signal conditioning. Its system operate for the real time and windows. The measurement type fro this model is voltage. It is used anti- aliasing filter or the signal conditioning. It is also can read the sample at 50 KS/s. he voltage rnge is -10 V to 10 V. It has the maximum voltage range accuracy which equal t 0.019 V. Special specification for this data acquisition is it can sample the data simultaneously. It is also can be used for all types of sensor. This data acquisition will detect the signal produced by the turbine which is the analog signal and the signal is converted into digital signal. This is because the Dasy lab software and the computer only can identify the digital signal instead of analog signal.The figures 3.12 and 3.13 are show the NI 9239 data acquisition and its chassis respectively.

Figure 3.12: NI 9239

Figure 3.13: NICDAQ9174 (the chassis)

3.4 SOFTWARE

The software that is used for this experiment is Dasy lab software. This software needs to operate simultaneously with the National Instruments software (Ni-MAX). The function of Dasy lab is to create an acquisition, collect the data, analysis task, control and simulation. There are many types of modules that contains in this Dasy lab software such as input/output module, control module, signal analysis module, display module, mathematics module and etc. This entire module can be very useful to collect the data and to analyse it. And the data from the experiment can be display using the display module. From this module also the data can be display with more attractive and it is easier to read or to observe data by creating layout instead of just using worksheet. So in order to conduct this experiment, the worksheet has been designed by using the modules that are needed for this experiment. The figure 3.14 shows the worksheet or the block diagram that has been created and being used for this experiment.

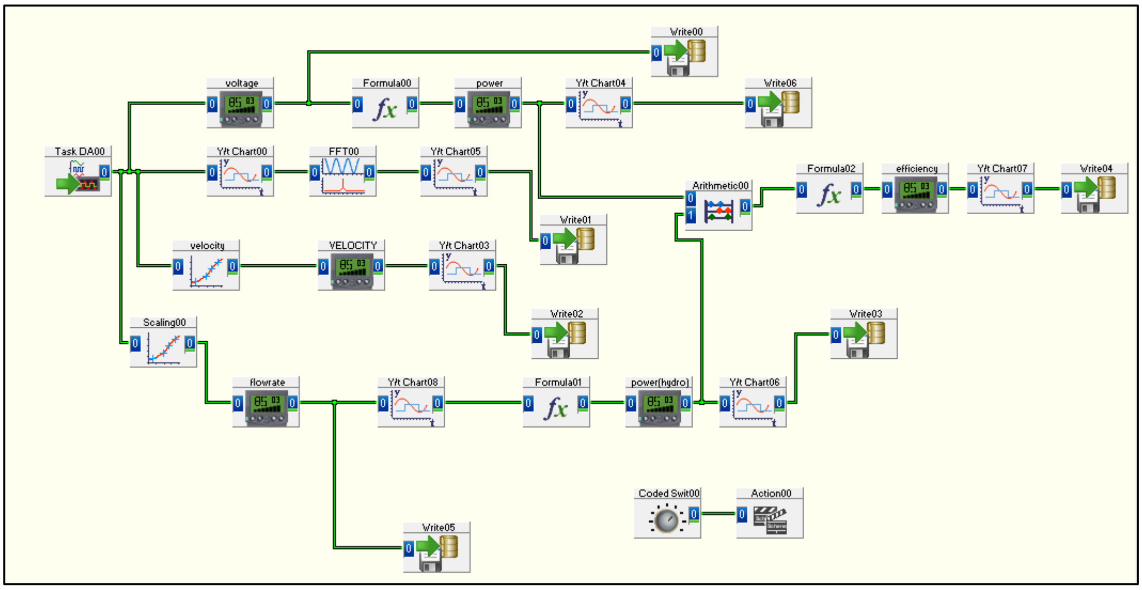

Figure 3.14: Worksheet

There are several modules that are been used in this experiment to create a worksheet that can collect and simulate all the data such as analog input module, formula, digital meter, y/t chart, scaling module, formula interpreter, arithmetic module, and write data module.

3.4.1 Analog Input Module

The analog input is selected from the browser section. And then this module is dragged into work area. There are several types of inputs/outputs module such as driver, DDE, RS232, Icom, NI- DAQmx. But for this experiment, the analog input module from the NI-DAQmx is used. This is because the signal has been detected and synchronised with data acquisition NI 9239 which is been discussed on subchapter 3.4. The function of this module is to acquire the data up to 16 signal inputs.

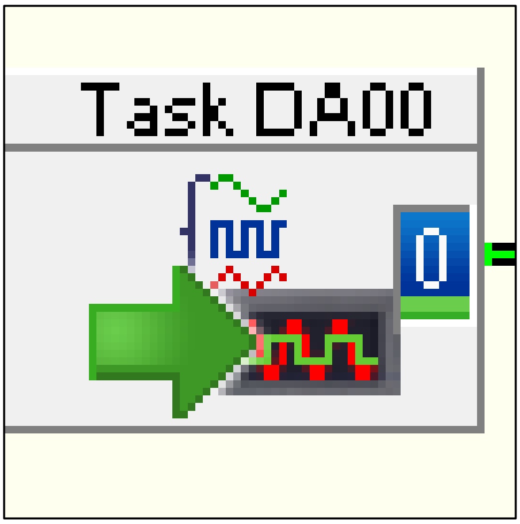

Figure 3.15: Analog input

3.4.2 Digital Meter

Digital meter is used to display the detect signal in digital. This module can perform in the difference mode such as RMS, single value, minimum value, maximum value, and mean value. For this experiment the mode of maximum value is used for this module. And the copy input box is tick to copy the data or input from the digital meter. There are five of these digital modules that have been used for this experiment. Five digital meters is used to display the voltage, power, power (hydro), velocity and the efficiency. Figure 3.16 and figure 3.17 show the digital meter module and its setting respectively.

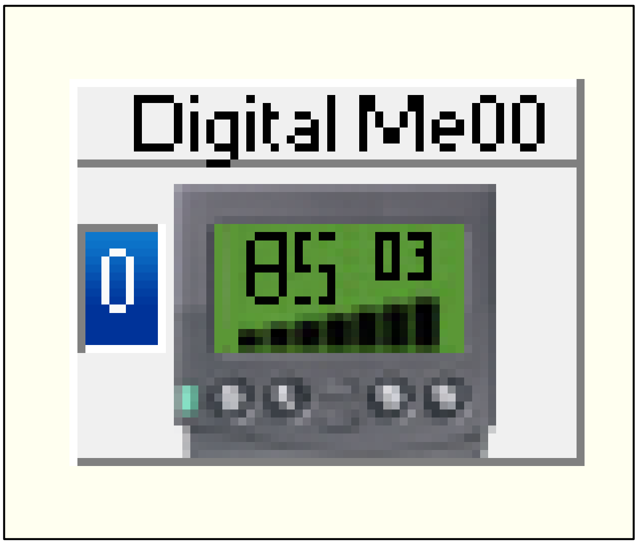

Figure 3.16: Digital meter

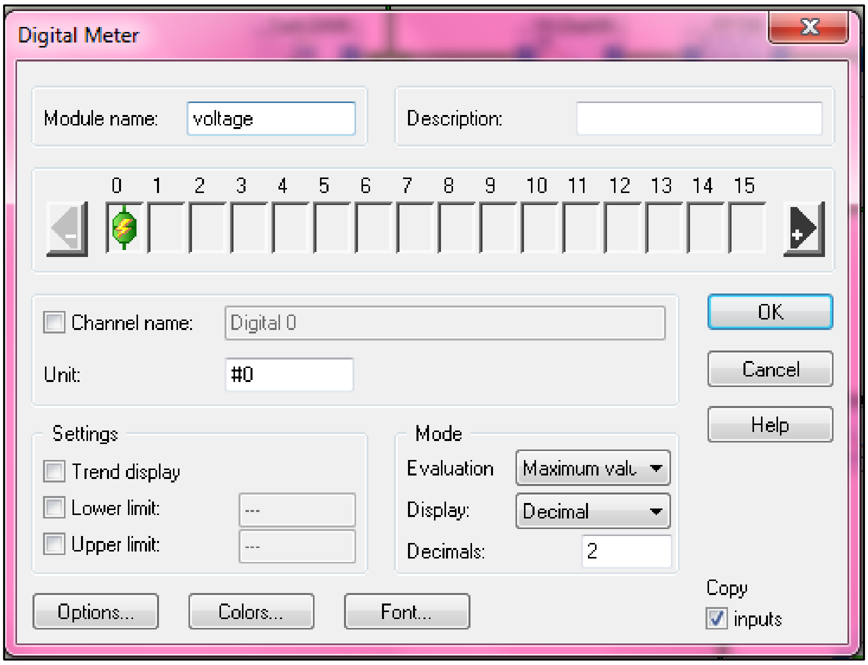

Figure 3.17: Digital meter setting

3.4.3 Y/t Chart

This module is used to display the data or input the form of graph instead of numbers. In others words, the y/t chart is used to display data channel in the form curve against time or curve against kilohertz. The figures 3.18 and 3.19 have shown the y/t chart and the setting chart respectively. The auto scaling box is tick so it will automatically scale the graph as shown in the figure 3.19.

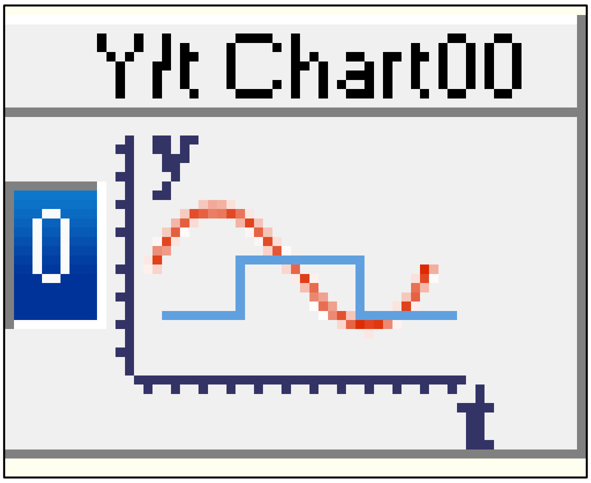

Figure 3.18: y/t chart

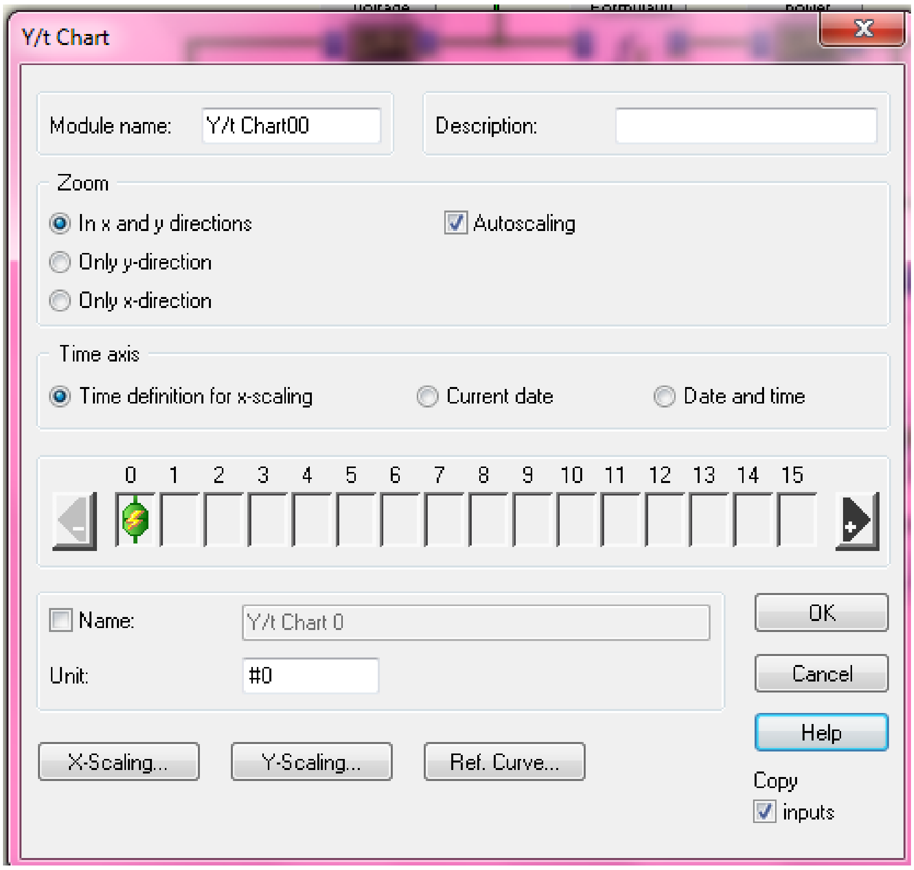

Figure 3.19: Setting of the y/t chart

3.4.4 Scaling Module

This scaling module is use to scale the value of voltage and flow rate. It is also been used to scale the voltage and the velocity. In this module there are four modes for linear interpolation setting. But for this experiment, linear interpolation with linear function is use. The linear function setting is ticked. In this setting there are the 'a' value and the 'b' value. The 'a' is actually represent the slope of the graph while the 'b' value represent the y- intercept of the graph. These values are obtained from the graph of calibration. This is will show on the subchapter 3.6 and 3.7. So for this experiment the a= 2.000000e-005 and the b=3.000000e-005. The figures 3.20 and 3.21 will show the scaling module and the setting of this module.

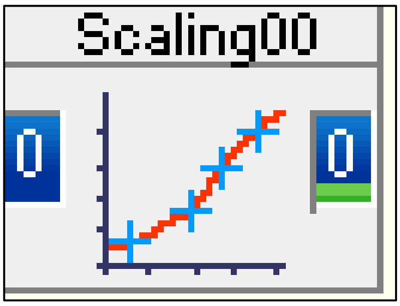

Figure 3.20: Scaling module

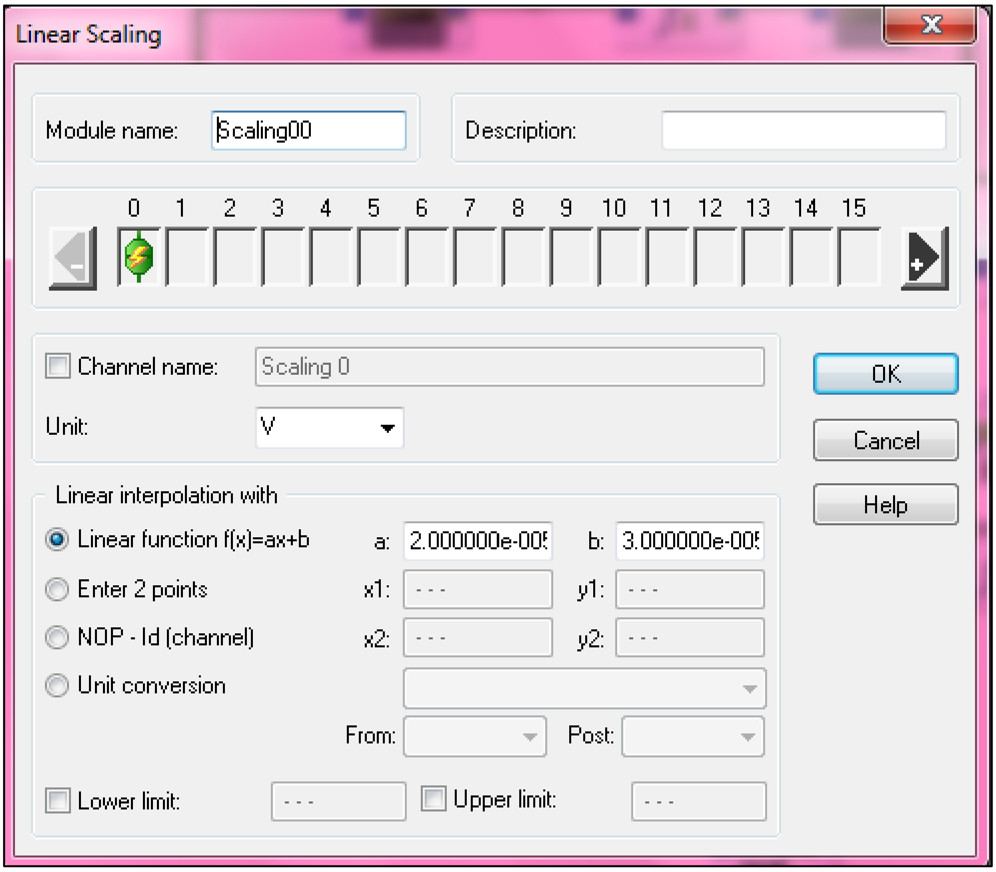

Figure 3.21: The setting of scaling module

3.4.5 Formula Interpreter Module

Formula interpreter module is used to interpret and calculate the data by using the formula that has been defined. So for this experiment the formula related is the electrical power formula P= VI. For example the data is voltage so the 'V' is being replaced with symbol 'IN (0)' and the 'I' is constant. For this experiment I=1.05 A. Instead of to calculate the electrical power value, the value of power produced by the hydro also calculated. This is will discussed more on the next subchapter. The figure 3.22 will show the formula interpreter module.

Figure 3.22: Formula interpreter

Formula is entered in the input field. There many setting in this module such as operators, inputs, trigonometry, constant, variables and functions. The figures 3.23 and 3.24 show the setting of the formula interpreter.

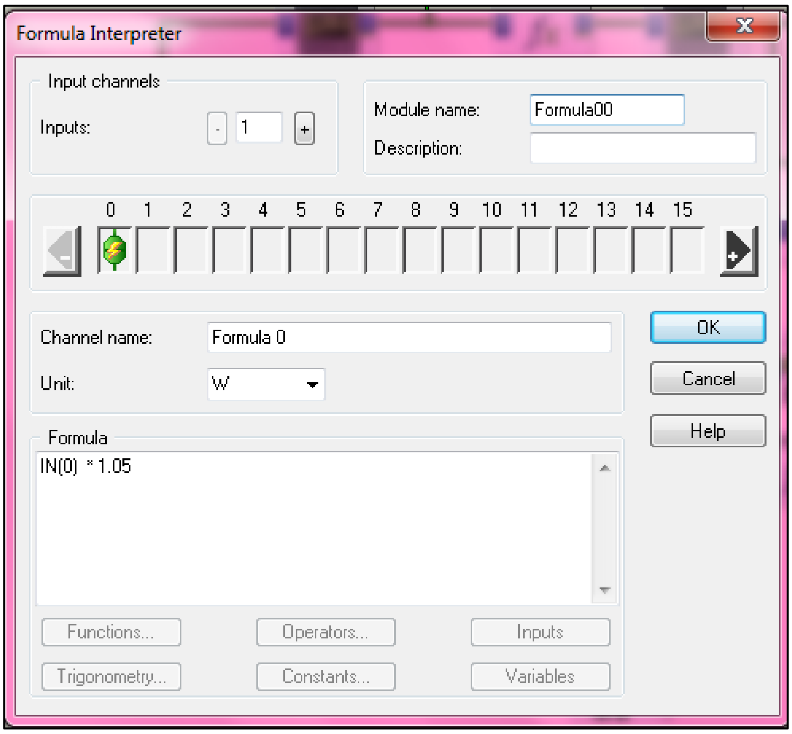

Figure 3.23: Formula interpreter setting

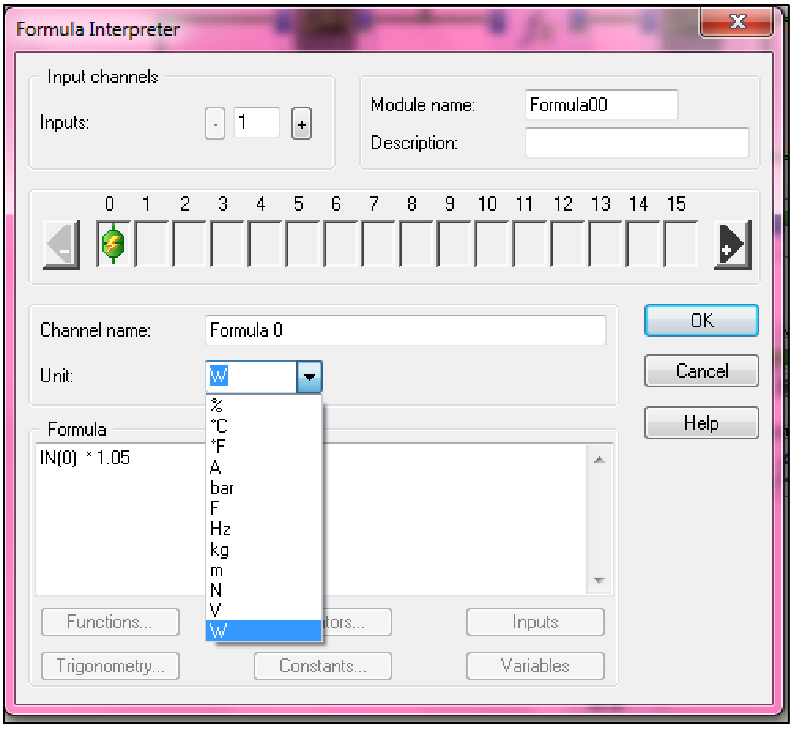

Figure 3.24: Formula interpreter setting (units)

From the figure 3.25 it is shown that how to change the unit for the formula interpreter. So on this experiment the unit W is used the unit for power, and power hydro is in watts (W).

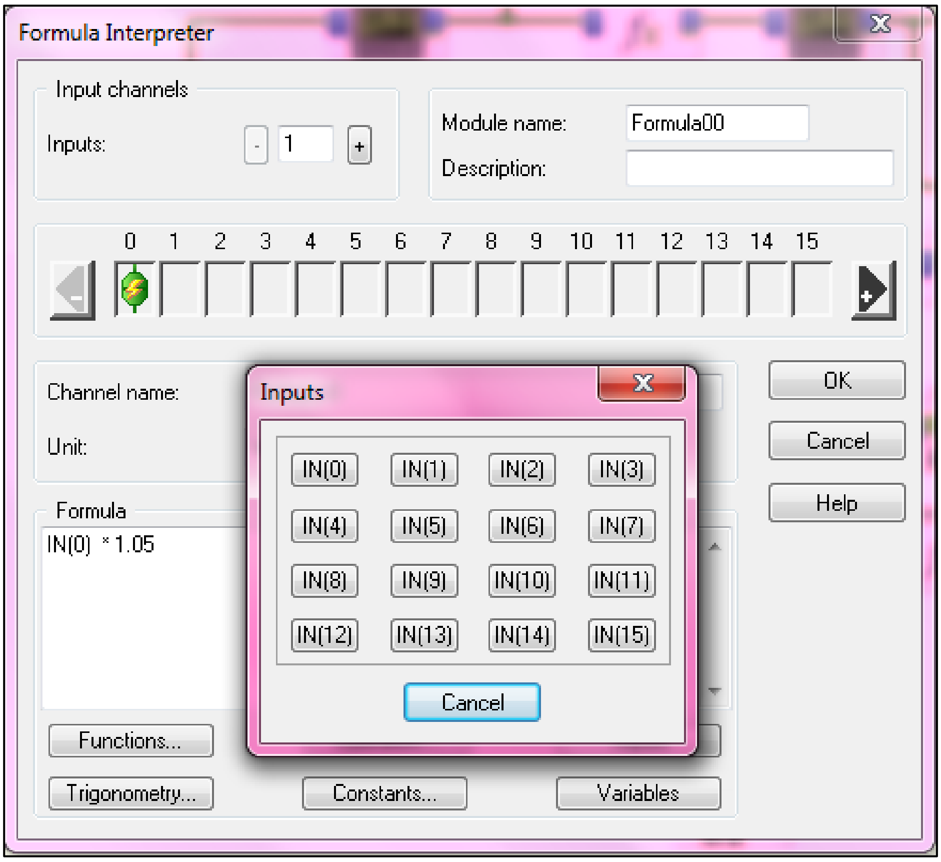

Figure 3.25: Formula interpreter setting (inputs)

The figure 3.25 has shown how to key in the formula. The inputs box is clicked. For this experiment IN (0) is chosen because the data is from channel number 0. If data came from the channel 1 so the IN (1) is chosen and so on. This is because the values 1 until 15 represent the input channel.

3.4.6 Arithmetic Module

This module is used to calculate the value of pair channel and it will output the calculation result. There are five channel operations can be done by this module such as add, divide, minus, and exponential operation. For this experiment the divide operation is used to determine the efficiency of the system. The figures 3.26 and 3.27 show the arithmetic module and the setting of this module respectively.

Figure 3.26: Arithmetic module

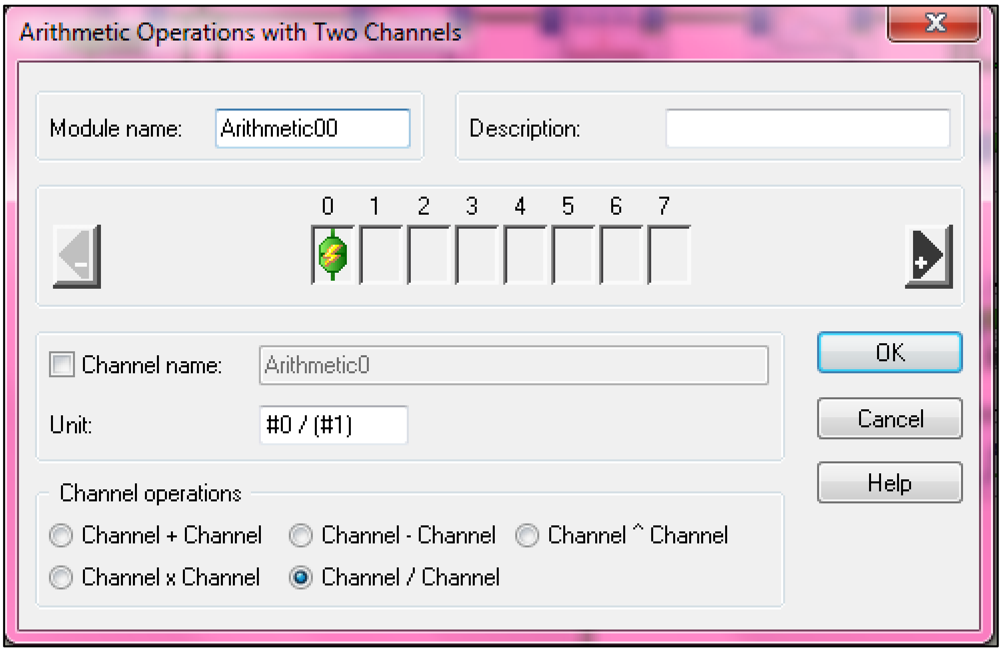

Figure 3.27: Arithmetic module setting

3.4.7 Write Data Module.

This module is used to save data automatically into excel format. It will automatically record the data while experiment is run. The figure 3.28 shows the write data module.

Figure 3.28: Write data module

The figure 3.29 shows the setting for the write data module. For this experiment the file format setting chosen is ASCII format in order to save the data in excel form.

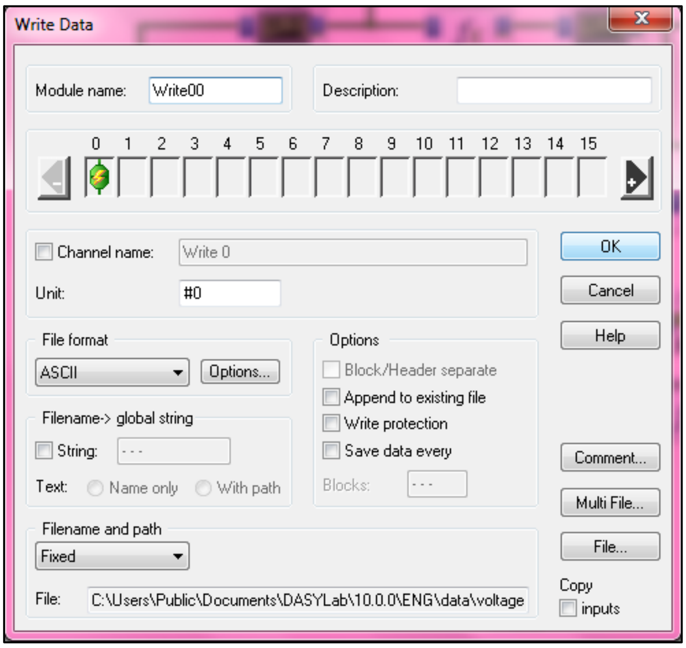

Figure 3.29: The write data setting

3.5 PROCEDURES

The experiment is conducted by switching the pipe level at the difference degrees such as 15°, 20°.40°.60°, and 90°.the purpose of this method is to give the variation of flow rate so the main objective of this study will achieved. Instead of that the H or head net is kept constant in this experiment. The value of H is 20 cm. The data is collected at every 20 second and the reading is taken 10 times at the difference angle of pipe opened. For example the pipe first is opened at 15° and 10 samples of data are collected at this angle. The gap between one sample to another sample is 20 second. After 10 samples have been taken then the step is repeated at others angle. There are several step to conduct this sexperiment such as calibration, turbine connection is identified, connection of data acquisition is identified, synchronization, pipe is opened and finally data is collected.

3.5.1 Calibration

The purpose of calibration is to calibrate the voltage and the flow rate and also velocity. The voltage is detected by using multimeter. The first value of voltage is detected when the highest flow rate is applied on the turbine by fully open the pipe at 90° and then the pipe is switched to 60°, 40°, and 20° in order to get the variation of flow rate. The voltage that is produced at these all degree is determined. The flow rate is calculated manually as shown in the figure 3.30 and the result and the sample of calculation of the calibration will be discussed more on the subchapter 3.7.

Figure 3.30: Calibration

The time taken for the water fulfils 1 litre of the beaker is recorded as shown in the figure 3.30. There are 4 readings that have been taken.

3.5.2 The Connection of the Turbine

The turbine is connected to the DAQ which is the NI9239. This data acquisition will convert the analog signal produced by the turbine to digital signal. The positive terminal of the turbine is connected to the input 0 and the negative terminal is connected to the input 1 of the channel number 1 at the data acquisition. The connection is as shown in the figure 3.31.

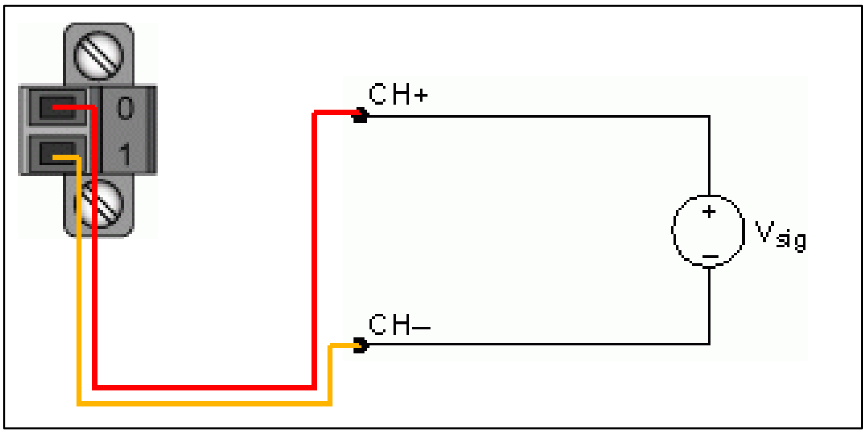

Figure 3.31: Connection of the turbine to NI9239

The figure 3.32 shows that the turbine is connected to wire by using the crocodile clip to make sure the connection is more safety. The red color is for positive terminal and the black color is for negative terminal.

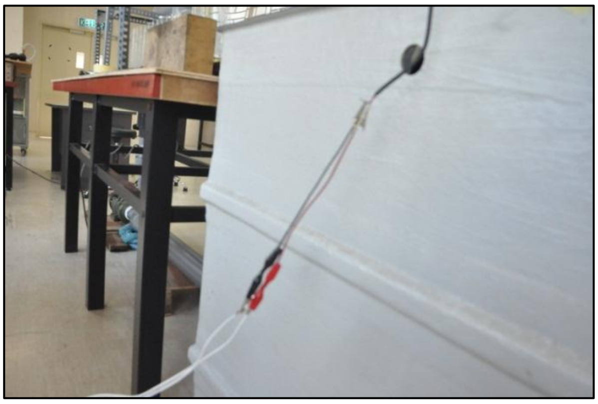

Figure 3.32: Connection of turbine with connection wire

3.5.3 The Connection of the NI9239 Data Acquisition.

The NI9239 data acquisition then is connected to the laptop by using USB cable. The connection is confirmed when the laptop can detect this data acquisition.

Figure 3.33: NI9239 is connected to the laptop

3.5.4 Synchronization

The pipe is open at 90° to detect the first signal produced by the turbine. This signal is detected by NI9239 through NI MAX software.

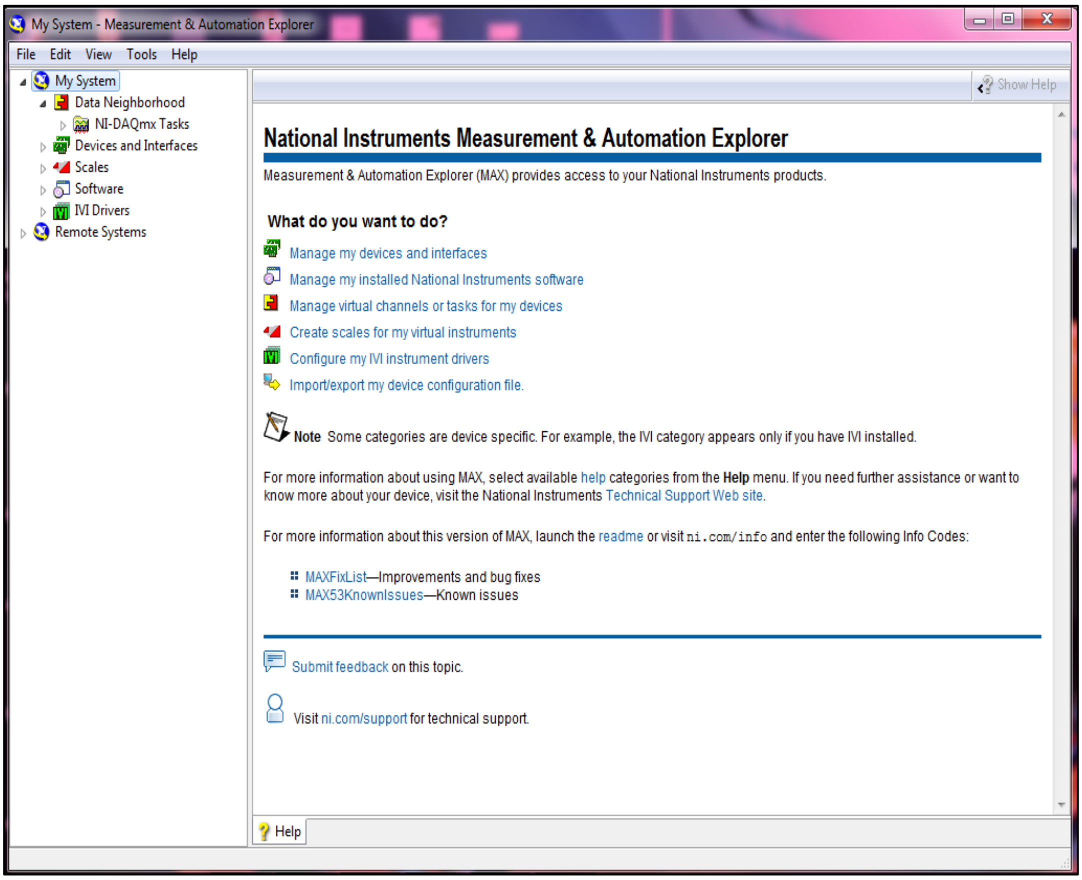

Figure 3.34: National Instrument software

A new task is created in this software. The task is specified. For this experiment the task is to acquire the analog signal which is the voltage signal. The step is shown as the figure 3.35.

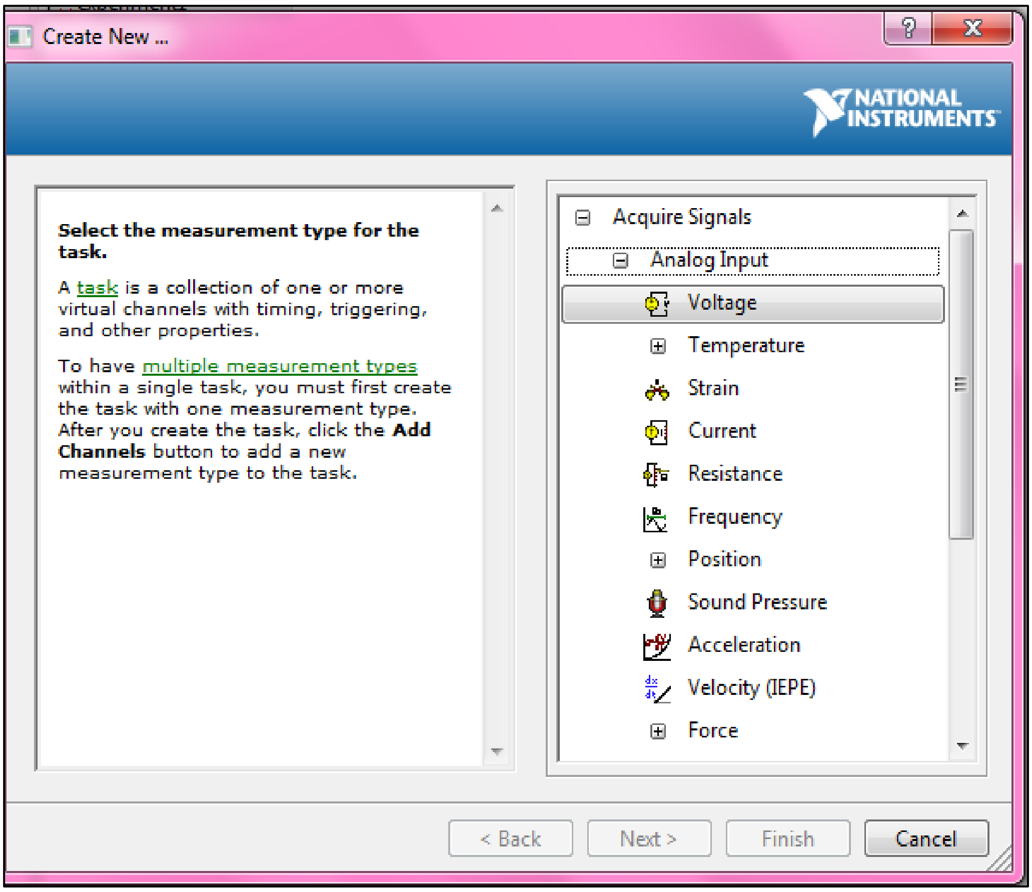

Figure 3.35: Acquired signal

Then this task is saved. The sample read is 1.6 k and the rate of sample is also 1.6k Hz. The sample that is read is voltage. This is because the acquire signal that had chosen is voltage. The acquisition mode used is continuous sample. The figure 3.36 shows the national instrument settings.

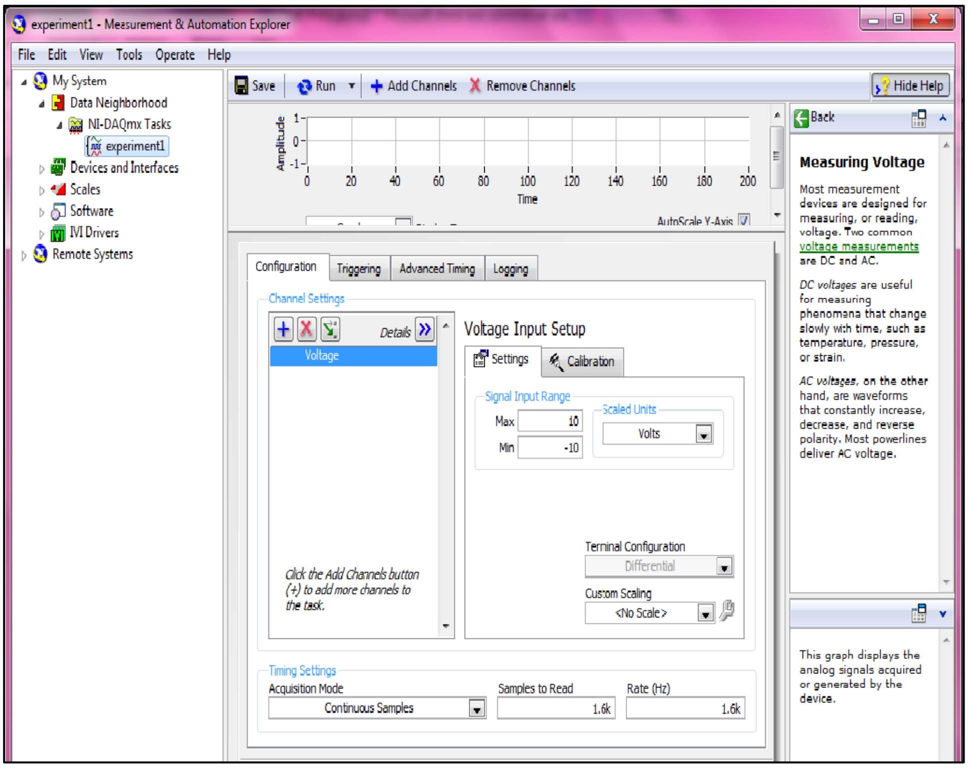

Figure 3.36: National instrument settings

Once these all step mentioned previous is done, the signal can be simulate, collect by using Dasy lab. But first of all, Dasy lab is synchronized with the national instrument software. This is as shown in the figure 3.37. The measurement browser is clicked and the option chosen is hardware setup. After that the NI-DAQmx option is click to synchronize wit MAX configuration which is National Instrument software.

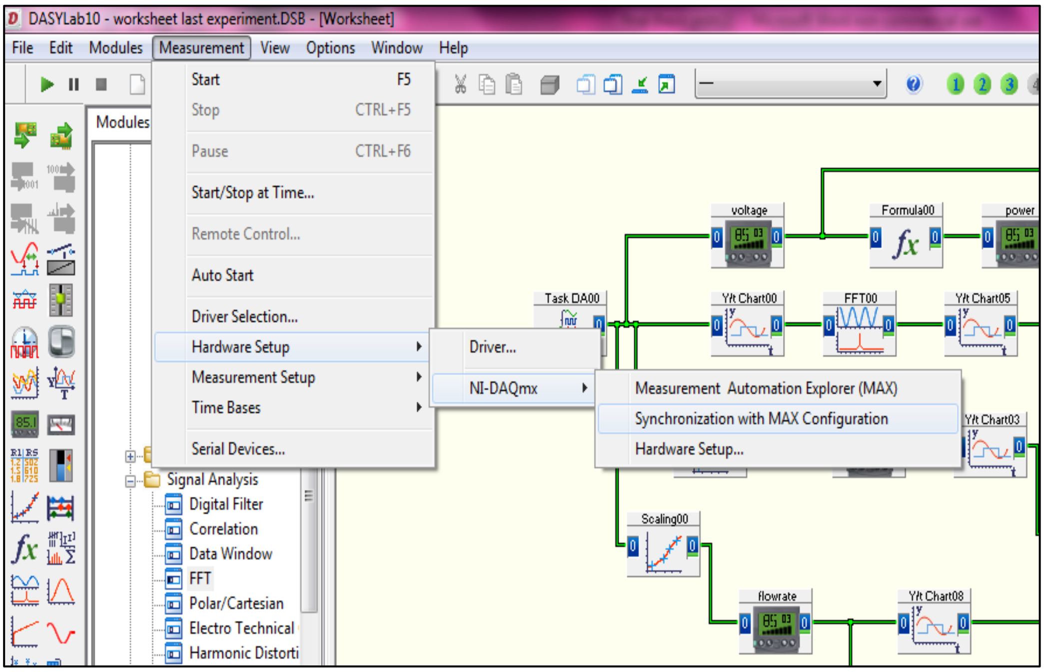

Figure 3.37: Dasy lab synchronization

After all of these setting have been set up, the experiment is started to collect all the data.

3.5.5 Pipe is Opened

First pipe is opened at 15° and followed by the 20°, 40°, 60° and finally 90° as shown in the figure 3.38, 3.39, 3.40, 3.41, and 3.42 respectively.

Figure 3.38: Pipe is opened at 15°

Figure 3.39: Pipe is opened at 20°

Figure 3.40: Pipe is opened at 40°

Figure 3.41: Pipe is opened at 60°

Figure 3.42: Pipe is opened at 90°

3.5.6 Data Collected

Data is then been collected at that difference degree of pipe opened. The value of flow rate, voltage, power and power (hydro) is then being determined at that specific degree of pipe opened. Data is collected by using Dasy lab software. The value of power is determined by using the formula P=VI that has been key in the formula interpreter module. The way to key in the formula has been discussed on the subchapter 3.4. The next figure 3.43 and 3.44 show the experiment was conducted.

Figure 3.43: Experiment was conducted

Figure 3.44: Experiment was conducted

Figure 3.45 show the signal is detected and the data is collected from the Dasy lab layout while this experiment was conducted.

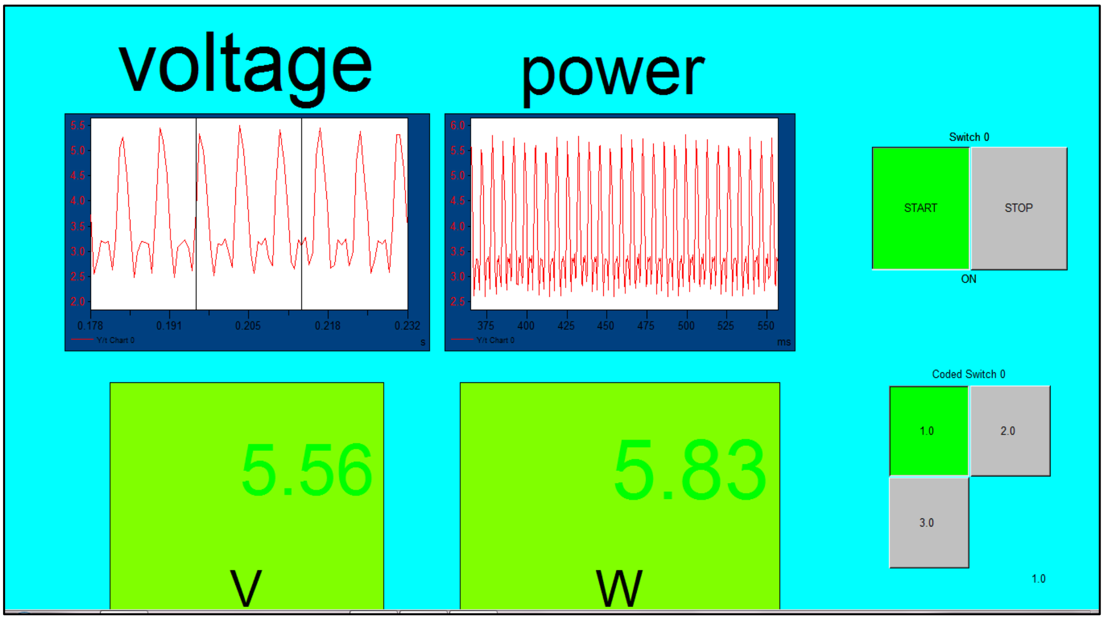

Figure 3.45: Data collected

3.6 SAMPLE OF CALCULATION (CALIBRATION)

This is the sample on how the flow rate and the velocity is calculated before been calibrated:

Q= flow rate (m^3/s)

V= velocity (m/s)

A= cross sectional vector area/ surface (m^2)

Voltage = 5.49V

D = 8mm

$A = \pi (r)^2$

r = 4.0E-3

$A = \pi (4.0E-3)^2 = 5.03$ E-5

Q =AV= $m^2 \cdot m/s$ (3.1)

= m^3/s

1 m^3 = 1000 L

0.001 m^3/6.806 s= 1L/6.806 s

Q = 1.4692 E-4 m^3/s

V= Q/A

= 1.4692 E-4/ 5.03 E-5

= **2.92 m/s**

3.6.1 Result of Calibration

On this part the result of calibration is shown. The table 3.1 will shows the voltage and the flow rate table for the calibration of flow rate with voltage.

Table 3.1: Table of calibration of flow rate

voltage	flow rate
3.96	0.000115
4.48	0.000123
4.81	0.000136
5.44	0.000147

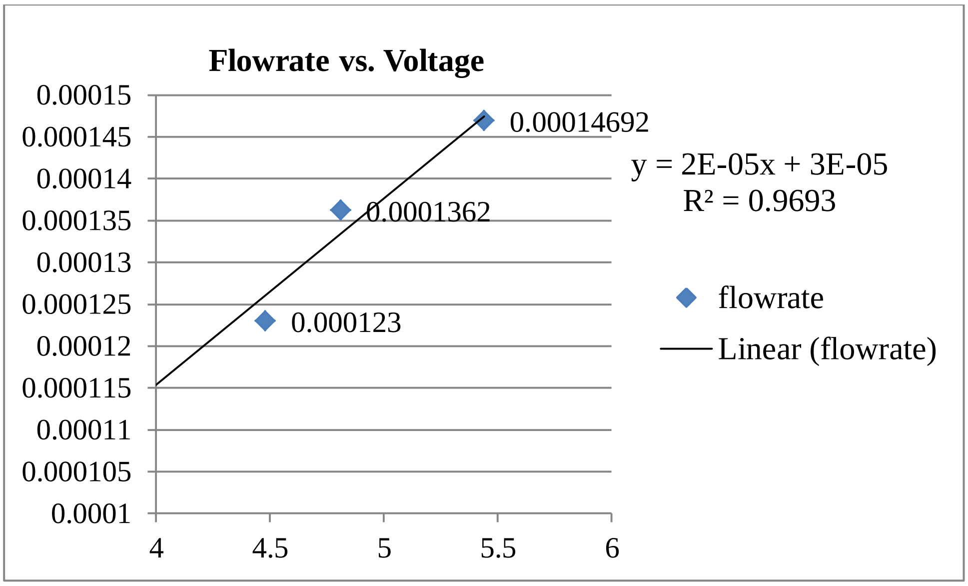

Figure 3.46: Calibration graph for flow rate

According from the graph from figure 3.46, the linear graph is obtained from calibration of flow rate with the voltage. In the meantime the linear equation and the R^2 value also is obtained. R value is the correlation coefficient of the graph. The linear equation for this graph and the R value are:

$$Y = 2E\text{-}05x + 3E\text{-}05 \qquad (3.2)$$

$R^2 = 0.9693$

This is the result of calibration of velocity and voltage. The table 3.2 will show the value of velocity and voltage.

Table 3.2: Table of calibration of velocity

Voltage (V)	Velocity (m/s)
3.96	2.29
4.48	2.45
4.81	2.71
5.44	2.92

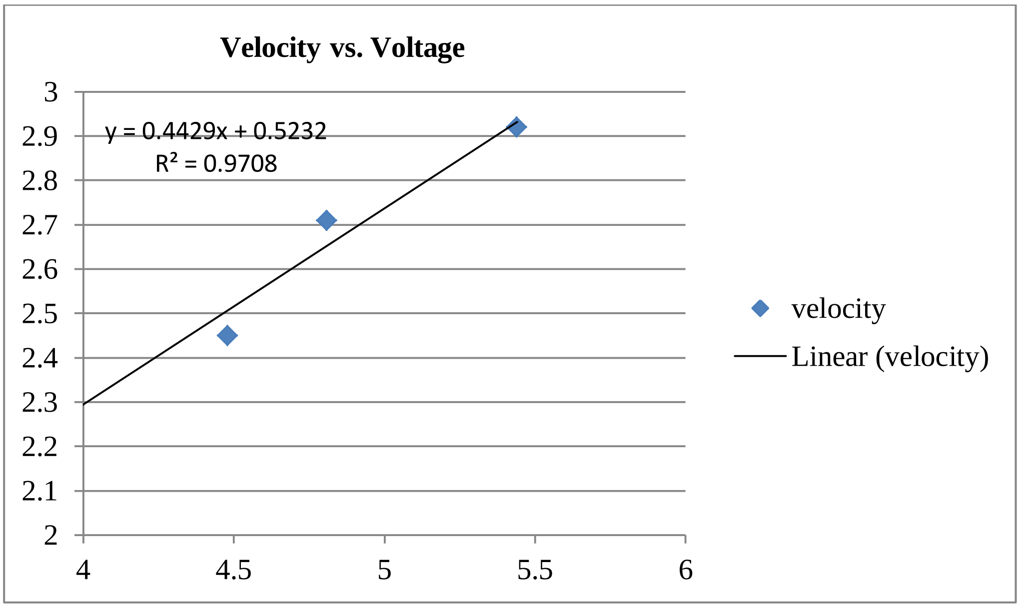

Figure 3.47: Calibration graph for velocity vs. voltage

According from the graph from figure 3.47, the linear graph is obtained from calibration of velocity with the voltage. In the meantime the linear equation and the R^2 value also is obtained. The linear equation for this graph and the R value are:

$$Y = 0.4429x + 0.5232 \quad (3.3)$$

$R^2 = 0.9708$

The linear equations that are obtained from both calibrations is used in the Dasy lab by scaling module as discussed in the subchapter 3.4. the basic equation for linear equation is:

$$f(x) = ax + b \quad (3.4)$$

So the value of a and b for the calibration of flow rate is:

a=2E-05, b=3E-05

Calibration of velocity:

a=0.4429, b=0.5232

3.7 SAMPLE OF FORMULA

There several formula that are been used to calculate the parameters in this experiment. The formulas mentioned are:

(i) The formula of Power of electrical

$$P = VI \quad (3.5)$$

P= instantaneous power measured in watts

V= the potential difference across the component measured in volts

I= is the current flow measured in amperes

The value of current use for this experiment is I= 1.05 A since according to the pump or turbine specifications.

(ii) The formula of power (hydro)

$$P = \eta \times \rho \times g \times H \times Q \quad (3.6)$$

P= Power of stream of the water measured in watts

η= efficiency of the turbine

ρ= density of the water (kg/m^3)

g= gravitational constant (m/s^2)

H= net head (m)

Q= volumetric flow rate (m^3/s)

The value of H and η used in this experiment are 20 cm and 0.9 respectively. The value of efficiency is referred from the table 3.1 because in this experiment the pump is function as the pelton turbine.

Table 3.3: Turbine efficiency

Turbine	**η**
Pelton	0.90
Banki- Mitchell	0.87
Turgo	0.85
Francis	0.90
Kaplan	0.90

Source: (Johnson, V.2008)

From the obtained result, the minimum and maximum value of the all parameters obtained is determined by averaging the parameters with the numbers of samples. The samples of formula involved are:

Number of samples = 10

Value of voltage $= \frac{\Sigma\, voltage}{number\ of\ samples}$

Value of flow rate $= \frac{\Sigma\, flow\ rate}{number\ of\ samples}$

Value of power $= \frac{\Sigma\, power}{number\ of\ samples}$

Power (hydro) $= \frac{\Sigma\, power\ (hydro)}{number\ of\ samples}$

CHAPTER 4

RESULTS AND DISCUSSION

4.1 DATA OBTAINED

Data is obtained after the experiment is done. Table 4.1, 4.2, 4.3 show the data obtained at the difference degree of pipe opened.

Table 4.1: Data obtained

Degree (°)	Time (s)	Voltage(v)	Velocitym/s	Power(W)	Powerhydro (W)	Flow rate(m3/s)
15	20	1.62	1.24	1.7	0.5509296	0.0000624
	40	1.64	1.25	1.72	0.5544612	0.0000628
	60	1.65	1.25	1.73	0.556227	0.000063
	80	1.66	1.26	1.74	0.5579928	0.0000632
	100	1.66	1.26	1.75	0.5579928	0.0000632
	120	1.67	1.26	1.75	0.5597586	0.0000634
	140	1.68	1.27	1.77	0.5615244	0.0000636
	160	1.68	1.27	1.76	0.5615244	0.0000636
	180	1.68	1.27	1.76	0.5615244	0.0000636
	200	1.69	1.27	1.77	0.5632902	0.0000638

Table 4.2: Data obtained (continued)

Degree (°)	Time (s)	Voltage(v)	Velocitym/s	Power(W)	Powerhydro (W)	Flow rate(m3/s)
20	220	2.55	1.65	2.68	0.715149	0.000081
	240	2.56	1.66	2.69	0.7169148	0.0000812
	260	2.57	1.66	2.69	0.7186806	0.0000814
	280	2.57	1.66	2.7	0.7186806	0.0000814
	300	2.58	1.68	2.7	0.7204464	0.0000816
	320	2.58	1.67	2.71	0.7204464	0.0000816
	340	2.58	1.66	2.7	0.723978	0.000082
	360	2.59	1.67	2.72	0.7222122	0.0000818
	380	2.59	1.67	2.72	0.7222122	0.0000818
	400	2.6	1.67	2.73	0.723978	0.000082
40	420	3.84	2.25	4.09	0.9517662	0.0001078
	440	3.9	2.25	4.09	0.953532	0.000108
	460	3.9	2.25	4.1	0.953532	0.000108
	480	3.9	2.25	4.1	0.953532	0.000108
	500	3.91	2.25	4.1	0.9552978	0.0001082
	520	3.92	2.26	4.11	0.9570636	0.0001084
	540	3.92	2.26	3.92	0.9570636	0.0001084
	560	3.92	2.26	4.11	0.9570636	0.0001084
	580	3.92	2.26	4.11	0.9570636	0.0001084
	600	3.92	2.26	3.92	0.9570636	0.0001084

Table 4.3: Data obtained (continued)

Degree (°)	**Time (s)**	**Voltage(v)**	**Velocitym/s**	**Power(W)**	**Powerhydro (W)**	**Flow rate(m3/s)**
60	620	4.26	2.41	4.47	1.0171008	0.0001152
	640	4.27	2.41	4.48	1.0188666	0.0001154
	660	4.27	2.42	4.49	1.0188666	0.0001154
	680	4.27	2.41	4.48	1.0188666	0.0001154
	700	4.28	2.42	4.5	1.0206324	0.0001156
	720	4.28	2.42	4.49	1.0206324	0.0001156
	740	4.28	2.42	4.5	1.0206324	0.0001156
	760	4.28	2.42	4.49	1.0206324	0.0001156
	780	4.29	2.42	4.51	1.0223982	0.0001158
	800	4.29	2.42	4.5	1.0223982	0.0001158
90	820	5.67	3.04	5.96	1.2660786	0.0001434
	840	5.68	3.04	5.97	1.2678444	0.0001436
	860	5.69	3.04	5.97	1.2696102	0.0001438
	880	5.7	3.05	5.99	1.271376	0.000144
	900	5.7	3.05	5.99	1.271376	0.000144
	920	5.71	3.05	5.99	1.2731418	0.0001442
	940	5.72	3.06	6.01	1.2749076	0.0001444
	960	5.72	3.06	6.01	1.2749076	0.0001444
	980	5.72	3.06	6	1.2749076	0.0001444
	1000	5.73	3.06	6.02	1.2766734	0.0001446

4.2 RESULTS

The data of voltage and the flow rate is illustrated in the form graph in order to show the relation of these two parameters. The graph that has been plotted is as shown in the figure 4.1.

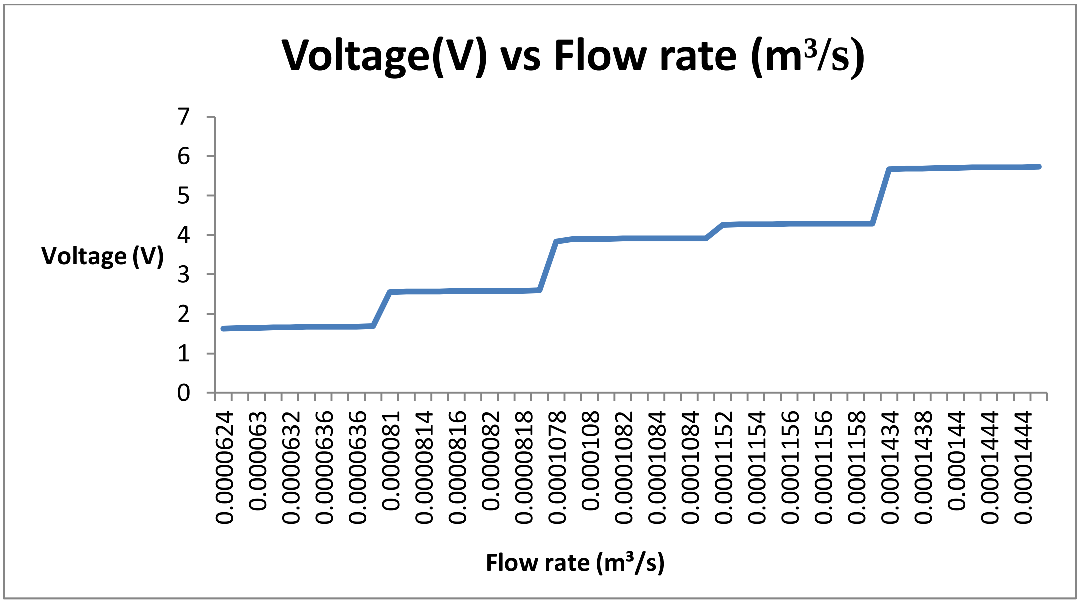

Figure 4.1: Graph of voltage vs. flow rate

The figure 4.1 has shown the voltage vs. flow rate. It is observed that the voltage is increased as the value of the flow rate was increased. The value of voltage is highest at the flow rate 0.0001444 m^3/s which is the highest flow rate that obtained from this experiment and the voltage has the minimum value at the flow rate equal to 0.0000624 m^3/s which is the lowest flow rate obtained from this experiment.

The average graph of voltage versus flow rate also is plotted to illustrate and to determine the average value of flow rate and the voltage produced when the pipe is opened at 15°, 20°, 40°, 60°, and 90°. The illustrated graph as shown in the figure 4.2.

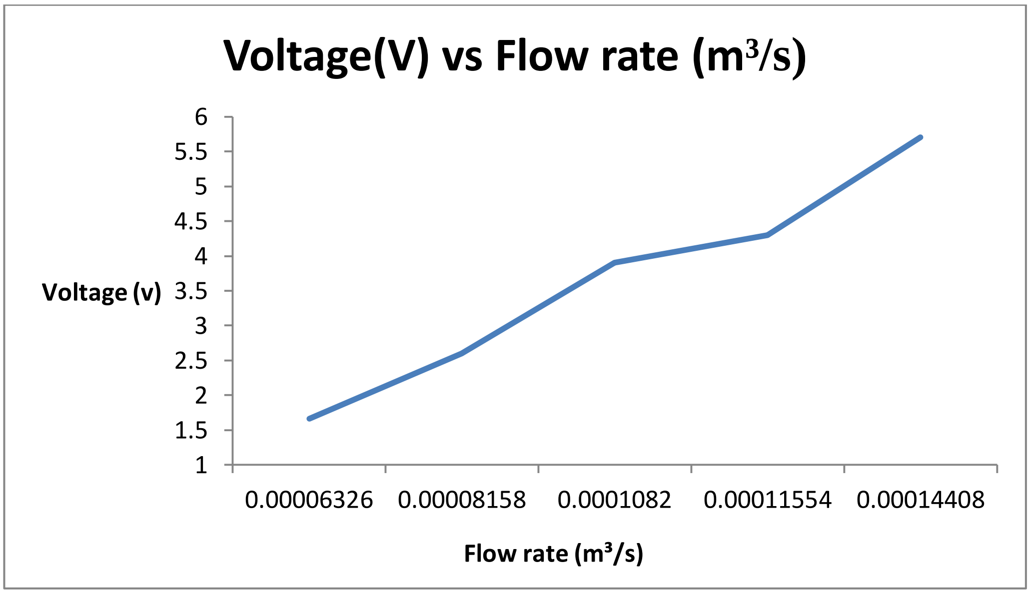

Figure 4.2: Graph of Voltage vs. Flow rate (average)

Figure 4.2 is shows the average reading at the specific degree of pipe opened. When the pipe opened at 15°, the average value of flow rate is 0.00006326 m^3/s and the voltage is 1.663 V. At the 20° the average flow rate obtained is 0.00008158 m^3/s ant the average value of voltage produced at this time is 2.6 V. Then at 40° the average value of flow rate is 0.0001082 m^3/s and the voltage is 3.9 V. At 60° the value of flow rate 0.00011554 m^3/s and the voltage is 4.3 V. the last one is the flow rate obtained at 90° is 0.00014408 m^3/s ant the voltage is 5.7 V. The calculation of these all average value is discussed on the previous subchapter 3.8.

In order to achieve the objectives of this study, the graph of power and power hydro vs. flow rate is plotted to study and to observe the relationship of these three parameters and how the flow rate will affect the electrical power produced by the stream of the water. The figure 4.3 shows graph of power and power hydro vs. flow rate.

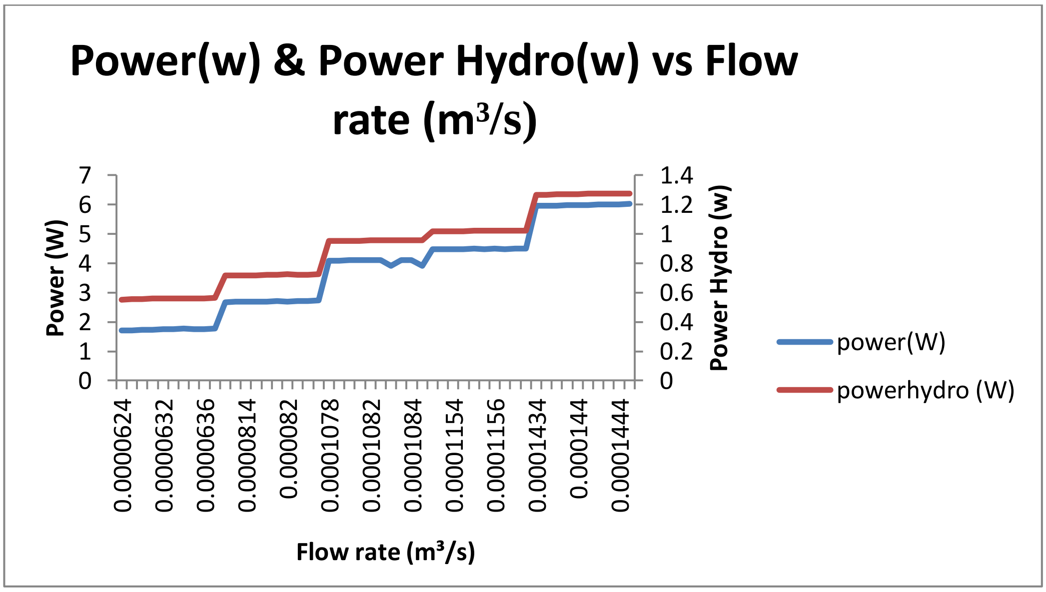

Figure 4.3: Graph of power and power hydro vs. flow rate

The figure 4.3 shows the relationship between the electrical power produced and the power produced by the stream of water and the flow rate. From the graph the blue line represents the electrical power while the red line represents the power hydro. From the graph, it is shows that, electrical power will increase as the flow rate. In others words, the biggest value of flow rate, the biggest value of electrical power will generated. The graph has the stairs shape. The value of the power start to increase at the flow rate equal to 0.0000638 m³/s, 0.0000818 m³/s, 0.0001084 m³/s, and 0.00001158 m³/s which is when the pipe is switch into 15°, 20°,40°,60°,90° respectively. The figure 4.4 shows the average value of power, power hydro, and the flow rate. These values are calculated by using the formula from the previous subchapter 3.8.

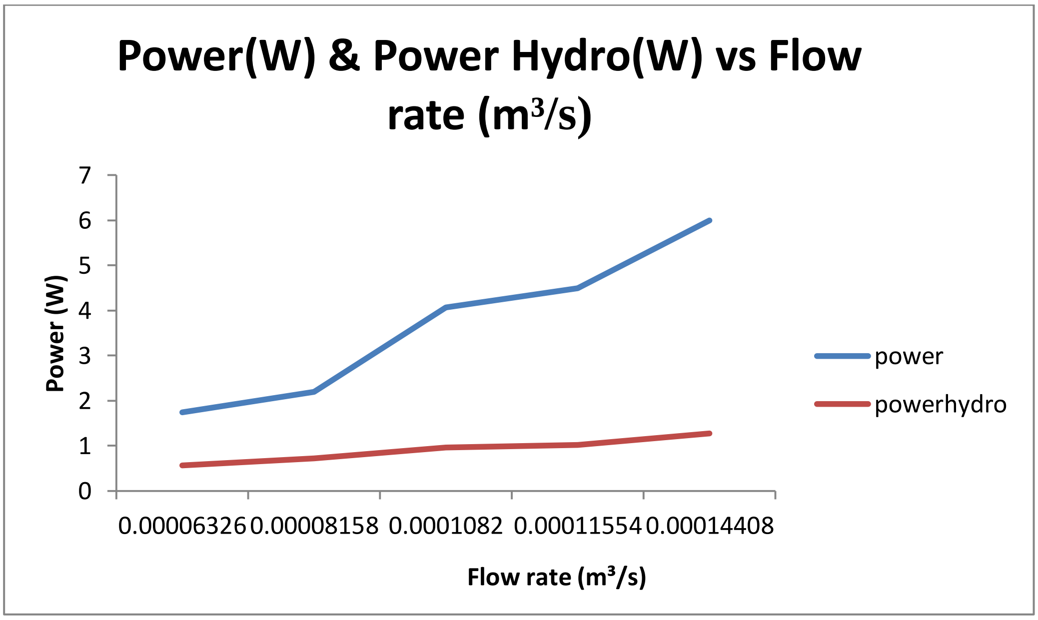

Figure 4.4: Power and power hydro vs. flow rate (average)

Figure 4.4 show the average value of power, power hydro and the flow rate. When the minimum flow rate is applied which is at 15° pipe opened, the average value of power produced is 1.745 W and the power hydro is 0.56 W. At the flow rate 0.00008158 m^3/s the average value of power is 2.2 W and the value of power hydro is 0.72 W. At the flow rate 0.0001082 m^3/s the value of power is 4.065 W and the power hydro is 0.96 W. when the flow rate at the 0.00011554 m^3/s it will produce the power is 4.5 W and the power hydro is 1.02 W. The last one is at the flow rate 0.00014408 m^3/s it is produced the value of power 6 W and the power hydro is 1.27 W.

4.3 DISCUSSIONS

From the figure 4.1 and 4.2 the graph had shown the value of voltage that generated at difference value of flow rate. From these two graph the value of minimum voltage produced is at the flow rate 0.00006326 m^3/s which is 1.663 V. the maximum voltage is 5.7 V and the flow rate is 0.00014408 $m^3/$. From this graph also it is been observed that if the flow rate is lowest than 0.0000624 m^3/s so there is no voltage will produced because the electrical voltage is produced when the potential energy that earned from the water stream is not enough to drive the shaft of the turbine and at the same time is not enough to create the mechanical energy at the turbine. So from this observation, the flow rate lowest than 0.0000624 m^3/s is not enough to supply or to create potential energy that will rotate the turbine and as the result the magnetic field inside the generator is not cut and at the same time the electrical is not produced. The graph is linear and this is shows that as the flow rate increase the voltage also increase. This is because the highest flow rate will create high potential energy that will drive the shaft of the turbine. This turbine will receive the potential energy as the mechanical energy and finally the generator of the turbine will convert it into electrical energy (Paish O, 2002).

`From the figures 4.3 and 4.4 it were shown that the relationship of flow rate and the power, power hydro produced. The graph is linear. This is proved that the increment of flow rate will cause the increment of power generated. According to the definition of electrical power, the electrical power is the product of the voltage and the current across the component. So from this definition, it is already known that higher flow rate will generate biggest potential energy that can afford to rotate the turbine and eventually will produce biggest voltage. So the power is the product of voltage and the current. So the higher the voltage produced the higher the power will be generated. Same goes to the power hydro. The increment of flow rate will cause the increment of power hydro. But the power hydro does not depend on the rotation of the turbine. It is only depend on the value of the flow rate. This is because, according to its formula, the power generated by the stream of the water is the product of gravitational energy, head net, density of the water, turbine efficiency, and flow rate (Paish O, 2002). So from this, it is observed that the flow rate can affect the power hydro generated because the flow rate is directly proportional to the power hydro produced. Power hydro is actually mechanical power produced at the turbine shaft. This power is actually come from the potential energy that has been applied by the flow rate of the water (Paish O, 2002). So the electrical power is depends on this power hydro or mechanical power. If this power hydro is high so it is eventually will create high value of electrical power. So from this experiment it is identified that the minimum value of power hydro and flow rate that will create the electrical power. If the flow rate is lower than the minimum value that obtained from this experiment, the electrical power is not produced as the value of power hydro also is low. So the maximum power generated by the turbine for this Pico hydropower is 6 W. This value is obtained when the flow rate of the water is at 0.00014408 m^3/s. The table

4.4 shows the prediction to supply the power generated by this Pico hydropower for several appliances.

Table 4.4: Predictions for electrical appliances

Appliances	Power rating (watts)	No of turbine (prediction)
Four fluorescent lamp	200	34
Television	100	17
refrigerator	300	50
computer	200	34

Since the maximum value of power obtained from this experiment is 6 W so the table 4.4 shows the prediction to supply the power produced for the electrical appliances. For an instant the turbine that is need to used to power the television is 17 turbines since the value of power produced by the turbines in this experiment is 6 W.

CHAPTER 5

CONCLUSION & RECOMMENDATIONS

5.1 CONCLUSION

From the experiment, the results obtained indicate that there is a positive correlation between power generated and the linear flow rate of the water. It is found that, the power generated by the turbine is increase as the flow rate of the water increase. This is to be expected as the first derivative of the mechanical power of the water, highly converted to the water's flow rate, is ultimately converted to the electrical power measured in the system. As the flow rate of the water of the water increases, it's expected that more power is generated. It is also noted that the turbine needs high flow rate to rotate and at the same time it will produced electrical power. If the power (hydro) or mechanical power is to small, the enough potential energy is not sufficicnet to rotate the turbine.

From the experiment, it is found that difference value of flow rate will generate difference value of power generated. The minimum flow rate applied in this experiment is 0.00006326 m^3/s produce 1.7 W of electrical power. The maximum flow rate applied in this experiment is 0.00014408 m^3/s produce 6 W of electrical power. These all findings can be made as a benchmark for the further research on the power produced by the Pico hydropower. For example, the minimum of flow rate found from this experiment can be as a benchmark for the future research, so the furture research will know the suitable flow rate in order to generate the electrical power.

This study has achieved the objectives to obtain the realationship between the flow rate of the water and the power that will generated by the Pico hydropower and also to find the value of the power that will generated at the certain value of the flow rate of the water.

5.2 RECOMMENDATIONS FOR THE FUTURE RESEARCH

This study was conducted by using one type of the turbine and the experiment was conducted in the created layout of the Pico hydropower. So for the future research, the experiment should be conduct in the real layout or environment such as at the river, waterfall and the suitable places to install the turbine. The blade that are used by the turbine in this experiment is not suitable for the fully immersed turbine or for the downstream flow. For the furture research, others type of blades that are suitable for the downstream flow should be used. From this, the study on array effect can be done. The best arrangement of the turbine installed in the water can be determined. After that the casing should be fabricated. This casing can install eight turbines in one time. This casing should be installed to in the river or flume in order to be tested. The power of this hydropower can be determined. The power produced can be supplied to the electrical appliances or to the user.

REFERENCES

A.M.A. Haidar. (2012). Utilization of pico hydro generation in domestic and commercial loads. *Renewable and sustainable energy reviews*.

Abbasi T. (2010). renewable and sustainable energy reviews. *small hydro and the environmental implications of its extensive utilization*, 3.

Abbasi T, & Abbasi SA. (2010). Their Impact on Global Warming and Pollution. *Renewable Energy Source*.

Bakis R. (2007). The Current Status and Future Opportunities of Hydroelectricity. *Energy Source*.

Belhadji, L. (2007). Modelling and control of variable-speed micr-hydropower plant based on axial-flow turbine and permanent magnet syncchronous generator.

Energy, M. o. (2010). *Booklets on Renewable Energy*.

I. Salhi. (2009). Fuzzy control of pico hydro power plants.

Johson, V. (2008). Fluid Flow in Pico hydropower.

Karl Heinz Fasol. (1990). Simulation. controller design and field test for a hydropower plant.

Norman S. Nise. (2004). *Control systems engineering*. John Wiley & Sons, Inc.

Paish O. (2002). Small hydro power: technology and current status. *Renewable & sustainable energy reviews*.

Ramos, S. (2009). Advantages of the Public Water Supply Use for Pico Power Generation.

Tick Hui Oh. (2010). Energy policy and alternative energy in Malaysia: issues and challenges for sustainable growth. *Renewable and sustainable energy reviews*.

W. Rameesha De Silva. (2006). Low Cost Voltage Regulator for Pico Scale Hydro.