TURBINE DESIGN EFFECT TO THE SPEED OF TURBINE AND OUTPUT VOLTAGE OF THE PICO-HYDROPOWER GENERATOR SYSTEM

HAZIQ IRFAN BIN HAMDAN

BACHELOR OF ENGINEERING TECHNOLOGY (ELECTRICAL & ELECTRONIC) WITH HONOURS

UNIVERSITI MALAYSIA PAHANG

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HAZIQ IRFAN BIN HAMDAN

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ABSTRACT

This report deals with the study on the turbine design effect on the performance of pico hydropower generator system in flowing water. The objective of this study is to design an easily installed and low costs Pico-Hydropower system for houses water tank to supply power for daily consumption. The objective of this project also is to test the type and capacity of loads to be supplied by the pico-hydropower and to study the performance of the developed Pico-Hydropower system in terms of Power (W), Voltage (V) and Current (A). The experiment was conducted by using the Pelton turbine and Turgo turbine printed by 3D-printer and choose which is most efficiency for this system. 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 electrical will happen. As the result, the electrical power is produced by the turbine. All the electrical power that produced of this project that Pico-Hydro power generator system will charge the battery or power bank. 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 result also indicates that difference value of the voltage will generate difference power. The power generated by turbine is depends on the flow rate because the high flow rate will create enough energy to rotate the blade of the turbine and at the same time the electrical power is produced.

ABSTRAK

Laporan ini membincangkan kajian mengenai kesan reka bentuk turbin terhadap prestasi sistem penjana kuasa hidro pico dalam air yang mengalir. Objektif kajian ini adalah untuk merancang sistem Pico-Hydropower yang mudah dipasang dan kos rendah untuk tangki air rumah untuk membekalkan tenaga untuk penggunaan harian. Objektif projek ini juga adalah untuk menguji jenis dan kapasiti beban yang akan dibekalkan oleh tenaga hidro pico dan mengkaji prestasi sistem Pico-Tenaga Air yang dikembangkan dari segi Daya (W), Voltan (V) dan Arus (A). Eksperimen ini dilakukan dengan menggunakan turbin Pelton dan turbin Turgo yang dicetak oleh pencetak 3D dan memilih mana yang paling cekap untuk sistem ini. Tenaga berpotensi yang dihasilkan oleh aliran air ditukarkan kepada tenaga mekanikal dan tenaga mekanik akan memutarkan bilah turbin. Semasa bilah turbin diputar, medan magnet di dalam generator telah dipotong dan aruhan elektrik akan berlaku. Hasilnya, tenaga elektrik dihasilkan oleh turbin. Semua kuasa elektrik yang dihasilkan dari projek ini yang dihasilkan oleh sistem penjana kuasa Pico-Hydro akan mengecas bateri atau power bank. Hasil yang diperoleh menunjukkan bahawa nilai kadar aliran mempengaruhi daya yang dihasilkan oleh turbin. Nilai daya yang dihasilkan oleh turbin meningkat seiring dengan peningkatan kadar aliran. Hasilnya juga menunjukkan bahawa perbezaan nilai voltan akan menghasilkan daya perbezaan. Tenaga yang dihasilkan oleh turbin bergantung pada kadar aliran kerana kadar aliran yang tinggi akan menghasilkan tenaga yang cukup untuk memutar bilah turbin dan pada masa yang sama tenaga elektrik dihasilkan.

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LIST OF SYMBOLS

%	Percentage
Ω	Ohm
km	Kilometer
rpm	Revolution Per Minute
V	Volt
mA	Miliamps
mm	Milimeter
A	Ampere
W	Watt
kHz	KiloHertZ
Hz	Frequency
ml	mililiter
mg/L	Miligram per liter
L/H	Liter Per Hours

LIST OF ABBREVIATIONS

PHP	Pico-Hydropower
IoT	Internet of Things
IPP	Independent Power Producer
TNB	Tenaga Nasional Berhad
LCOE	Level Costs of Energy
USGS	United States Geological Survey
HP	hydropower
IDE	Integrated Development Environment
BLDC	Brussless Direct Motor
PLA	3D Printer Filament
3D	3 dimensions
LCD	Liquid-crystal display
LED	Light Emitting Diode

CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Water is an important resource because it is needed for life to exist. Many uses of water included agricultural, industrial, household, recreational, and environmental activities. Virtually all of these human uses require fresh water.[1] According to the researched by United States Geological Survey (USGS), a person used about 80-100 gallons of water per day for indoor home uses. In case of a resident house containing of 5 peoples, there are approximately used up to 500 gallons per day. Hydroelectric power classed as a renewable energy which changed form kinetic energy to electricity. In 2016, hydro supplied a straggling 71% of all renewable electricity generated.[2] The hydropower (HP) is the world's largest and the most efficient sustainable way to produce electricity or power.[4]

Nowadays, HP is employed for converting 90% of the energy of moving water into electricity/power. This can be comparable to the fossil fuels (FFs) based power plants, which are maximum only 60% efficient.[4] There are several types of hydropower plant and they all powered by the kinetic energy of flowing water as it moves downstream. Water dams are created to store the water for use as when required. About 75% of the existing 45,000 large water dams in the world were built for the purpose of flood control, irrigation, navigation, and urban water supply. Whilst around 25% of large reservoirs are used for hydropower and multi-purpose reservoir purposes. [2]

The first type is the most common type of hydropower plant used a man-made dam on a river to store water in a reservoir.[2] It also called as an Impoundment hydropower plant since they store water for later consumption. The generating station are located at the dam toe or further downstream, connected to the reservoir through tunnels or pipelines. Figure 1.1.1 show the type and design of reservoirs are decided by the landscape and in many parts of the world are inundated river valleys where the reservoir is an artificial lake. In geographies with mountain plateaus, high-altitude lakes make up another kind of reservoir that often will retain many of the properties of the original lake. For example, in Scandinavia, natural high-altitude lakes are the basis for high pressure systems where the heads may reach over 1,000 m. One power plant may have tunnels coming from several reservoirs and may also, where opportunities exist, be connected to neighbouring watersheds or rivers. The design of the HPP and type of reservoir that can be built is very much dependent on opportunities offered by the topography. [3]

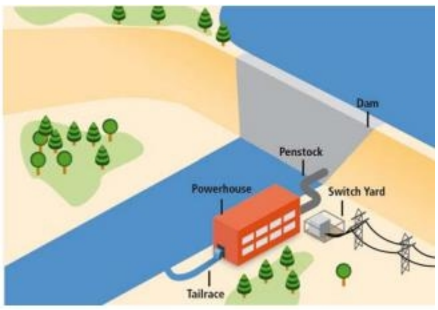


Figure 1.1.1 Impoundment Hydropower Plant (Storage Hydropower Plant) [3]

The second type is Run-of-River hydropower plant. A Run-of-River hydropower plant also known as run-of-the-river is where little or no water is stored or dammed. Because of no water storage, it is subjected to sustainable daily, monthly or seasonal variation, thus the plant will operate as an intermittent energy source.

Such a hydropower plant may include some short termsstorage (hourly, daily), allowing for some adaptations to the demand profile, but the generation profile will to varying degrees be dictated by the local river flow conditions. In a run-of-river hydropower plant, a portion of the river water might be diverted to a channel or pipeline (penstock) to convey the water to a hydraulic turbine which connected to an electricity generator. Figure 1.1.2 show the installation of run-of-river hydropower plant is relatively inexpensive and such facilities have, in general, lower environmental impacts than similar-sized storage hydropower plants. [2,3]

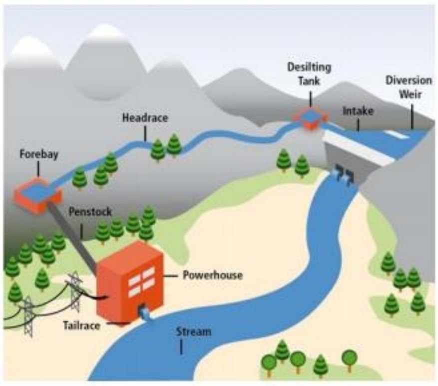


Figure 1.1.2 Run-of-River Hydropower Plant (Diversion) [3]

The third type is Pumped Storage Hydropower Plant. The pumped storage hydropower plant works like a battery, which its system pumped the water from the lower reservoir into upper reservoir, usually during off-peak hours, while flow is reversed to generate electricity during the daily load period or at other times of needed. Although the 4 losses of the pumping process make such a plant a net energy consumer overall, the plant is able to provide large-scale energy storage system benefits. Figure 1.1.3 show the pumped storage hydropower plant. [2,3]

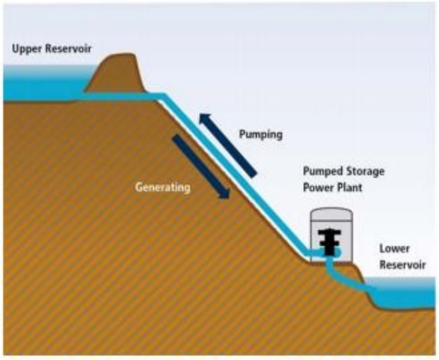


Figure 1.1.3 Pumped Storage Hydropower Plant (PSH) [3]

The Levelised Costs of Energy (LCOE) represents the lifetime costs of production including construction without subsidies or any intervention. This is a good method of comparing different energy types over the lifetime of power plants. Hydro power has the lowest LCOE different forms of renewable energy (World Energy Council report, 2016). What is particularly interesting is the downward costs of onshore wind and phenomenal rate of reduced costs of solar PV.

The below chart shows the cost of electricity taking into accounted construction costs including profits the complete life cycle cost of kWh of energy. In 2015 the cost of electricity from hydro was 0.046 USD per kWh. [3]

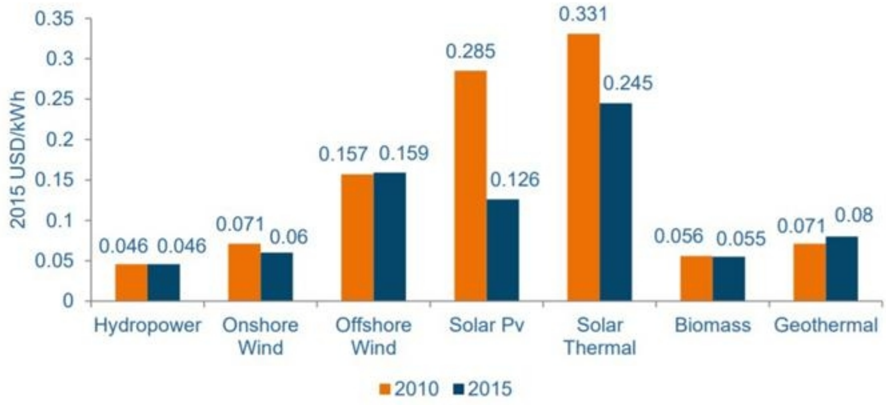


Figure 1.1.4 Cost of energy taking in year 2010 and year 2015 by LCOE [3]

From the Figure 1.1.4 the construction fees and maintenance fees for a Solar Power Plant is higher than the hydropower plant, it will be affected the profit of the power plant. Since 2011, Feed-in Tariff is available in Malaysia to increase investment in renewable energy sources. Malaysia's Feed-in Tariff system grants you the opportunity to sell your energy produced using solar system to utility grid (TNB) at a premium rate.

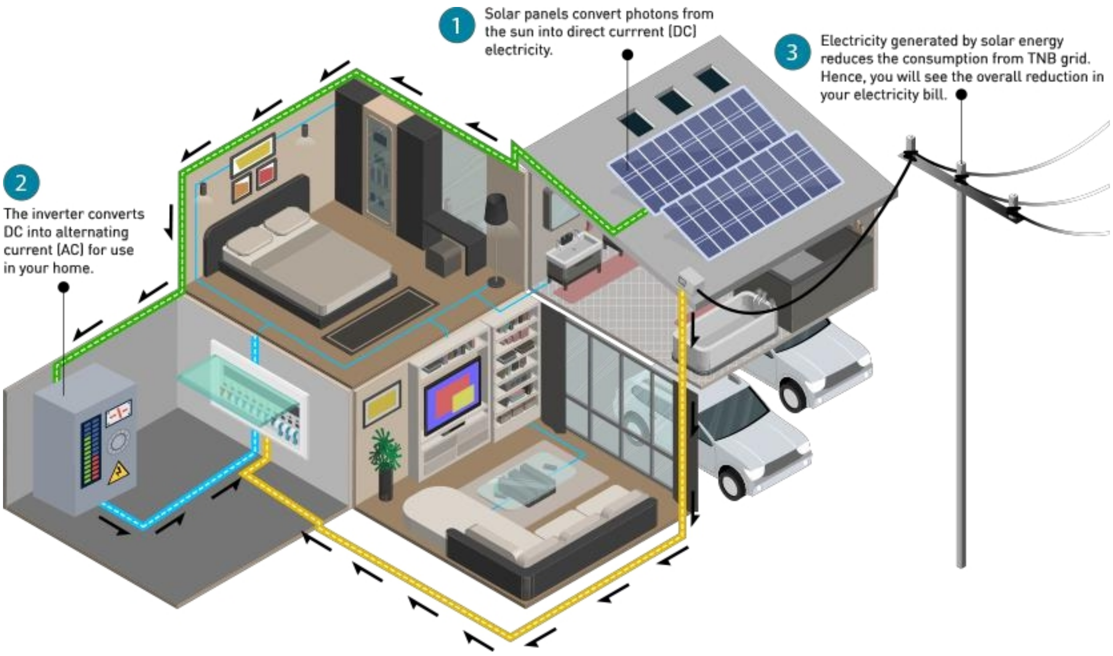


Figure 1.1.5 Feed-in Tariff by TNB

Table 1.1.1 Size of Hydropower [3]

Hydropower Categories	Power Range
Large	More than 100MW
Medium	25 - 100MW
Small	1 - 25MW
Mini	100kW - 1MW
Micro	5 - 100kW
Pico	Less than 5kW

The high expenditure and adverse environmental concerns that associated with the use of large HP plants have helped to focus the attention on small or Pico-scale HP plants, which reduce these affects considerably. Pico hydropower (PHP) offers an efficient, reliable and cost effective of alternative power sources. In addition, the demand for PHP in the market shows that PHP is the best and low-priced choice for rural or remote area electrification in developing nations. Nevertheless, the PHP technology is still considered as a brand-new in Malaysia. As of 1st October 2014, total generated capacity of power in Peninsular Malaysia stood at 21,060 MW, 52% of total power was generated by Tenaga Nasional Berhad (TNB, the only electric utility company in Malaysia and the largest in ASEAN), while the remainder (48%) was generated by independent power producers (IPPs). [4,5,6]

Most of the water tank located at the rooftop of the house, this is because it can use the gravitational forces to maintain a high speed of water flow and provided to consumer without using a water pump. The type of turbine will directly affect the performance of the hydropower plant. The water in to the water tank it will has an impact, this will be caused to choose an impulse turbine as our references.

1.2 PROBLEM STATEMENT

1.2.1 Cost and location to install solar panel higher than pico-hydropower

In the year of 2011, the government of Malaysia and utility companies such as Tenaga National Berhad (TNB) offer programs which called Feed-in Tariff. The Feed-in Tariff is installed a solar panel at the rooftop of a house. The installation fees for a terrace house is around RM 19,000. [8] Besides that, most of the Pico-hydropower system installed at river and waterfall. For instant, the different part of the river or waterfall has different flow rate at the same time it will produced an unstable voltage supply to maintain its operating. [9,10] For example, pico-hydropower system unsuitable to install at the country which has dry season and winter season. Besides that, the different section of the river it has a different water flow rate. The different flow rate will affect the type of turbine used to get the best performance of the pico-hydropower system. [11] The first problem is cost and location to installed a pico-hydropower in house is less than RM 600.00 it is cheaper compared to solar panel and the location to install and maintenance is easier than solar penal.

1.2.2 Efficiency of impulse turbine

Pelton turbine, Turgo turbine, Crossflow turbine and Multi-jet Pelton turbine is the categories of impulse turbine. Impulse turbine which convert all the pressure energy of water into the kinetic energy through the nozzle and generated high speed jet water. But the reaction turbine is pressure change of water when passes through the rotor of turbine. [12] After a research, most of the experiment used Turgo and Pelton turbine. Turgo turbine is the half cut of Pelton turbine, but none of one research can prove that which of the turbine is the best and suitable for any situation. The problem is to test and tabulate both of the turbine which is more efficiency in the system.

1.3 PROJECT OBJECTIVE

The main aim of this project is to develop a low cost and effective Pico-Hydropower Generated by Water Flow in Water Tank. To accomplish this, the following objectives must be achieved:

1) To design an easily installed and low costs Pico-Hydropower system for houses water tank to supply power for daily consumption.

2) To study and tested the Pelton turbine and Turgo turbine printed by 3D-printer and choose which is the most efficiency for this system.

3) To study the performance of the developed Pico-Hydropower system in terms of Power(W), Voltage(V), and Current(A).

4) To test the type and capacity of loads to be supplied by the pico-hydropower.

1.4 SCOPE OF DISSERTATION

The scope that are related to this project are:

1) To study focuses and designing a low costs Pico-Hydropower system that can produce power supplied to the household appliances and decrease the usage of energy.

2) Establishing a control system through Arduino to control the water flow by solenoid water valve.

3) Utilizing a suitable turbine to produce a most efficiency Pico-Hydropower system.

1.5 Expected Outcome

The expected outcome of this project is that the Pico-Hydropower generator system will charge the battery or powerbank. First of all, when the water tank is empty, the water level sensor will scan the water level and it will send a pulse to Arduino UNO and the Arduino will open the solenoid valve to let the water in. Next, the water in will hits the turbine and the turbine connected with the PMA brushless DC motor by a gear will rotate and generated a power. The power will charge the battery or powerbank. Beside that, when the water is fully filled the water tank, the water level sensor will send a pulse to stop the water into the water tank. In the expected output result, the Pelton turbine will be more efficiency than the turgo turbine.

1.6 Reality Outcome

The process of the pico-hydropower generator system is change from kinetic energy to electrical energy. In this process, there will be some energy loss have to included. First is the power loss, which according to research, the power generator has 50% of power loss in the process. Besides that, when the water hits the turbine there will be some friction force and it will cause the power loss on the turbine. Moreover, there are some small power loss which is gear loss.

Furthermore, the efficiency of the turbine has affected by many factors. First is the design of the turbine, and this turbine is built by a 3D-printer, the surface of the turbine if rough, and it will cause a lots of friction force on the turbine. Beside that, the direction of the water to hits the turbine is also have a different to affected the efficiency of the turbine.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

In this chapter, we will discuss the historical background of the Pico-Hydropower, concept of the system, equipment, and some related works. Some examples, of the hardware and software that are used in this project will also be mentioned.

2.1 Historical Background of Hydropower

Hydropower started with the wooden waterwheel. Waterwheels of various types had been in use in many parts of Europe and Asia for some 2,000 years, mostly for milling grain. By the time of the Industrial Revolution, waterwheel technology had been developed to a fine art, and efficiencies approaching 70% were being achieved in the many tens of thousands of waterwheels that were in regular use. Improved engineering skills during the 19th century, combined with the need to develop smaller and higher speed devices to generate electricity, led to the development of modern-day turbines. Probably the first hydro-turbine was designed in France in the 1820s by Benoit Fourneyron who called his invention a hydraulic motor. Towards the end of that century many mills were replacing their waterwheels with turbines, and governments were beginning to focus on how they could exploit hydropower for large-scale supply of electricity. [20]

2.2 Introduction of Pico-Hydropower

Pico hydro is the hydro electricity generation methods with the maximum electric output of five kilowatts. The recent improvement and innovations in Pico hydro technology have made it an easily available economic source of power even at remote places around the globe. This is a very versatile power source that could be used to generate AC electricity. Light bulb, radio, television and other similar electronic devices can be easily operated by using the Pico hydro power.

The need of pico hydroelectricity around the world is that it allows electricity generation simply and at no fuel cost. The growing high demand in electrical energy is forcing man to search for different available energy resources. The equipment's used in pico hydroelectricity generations specialised with its small and compact design, so that it could be installed in a small area very easily. The main benefit of pico hydroelectric power generation is that it has a lower cost per kilowatt compared to that of solar or wind power. So pico hydro system is unthoughtfully recommended in places with regular water flow. [29]

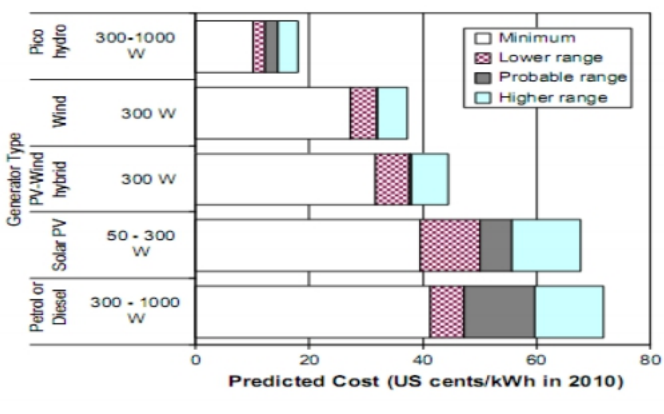


Figure 2.1: Predicted cost for off-grid electricity – data from World Bank [27]

According to the Figure 2.1 above, pico-hydropower is the lowest cost hydropower compare to other types of generator therefore pico hydro has been proposed in this project.

Normally, pico-hydropower system is found at rural or hilly area. This system will operate using upper water reservoir which is a few meters high from ground. From the reservoir, water flows downhill through the piping system. This downhill distance is called "head" and it allows the water to accelerate for prime moving system. Thus, the turbine will rotate the alternator to produce electricity. [29]

2.3 Multi-Criteria for available Turbine

Selecting hydro turbines is based on the specific speed of the turbine, a nondimensional parameter that includes head, output power and output shaft speed. Figure 2.3 show the commonly used application domain for turbine is used to aid selection. This leads to the choice of Pelton and Turgo turbines at high heads, crossflow and radial (Francis) turbines at mid heads and propeller turbines and waterwheels at low heads.

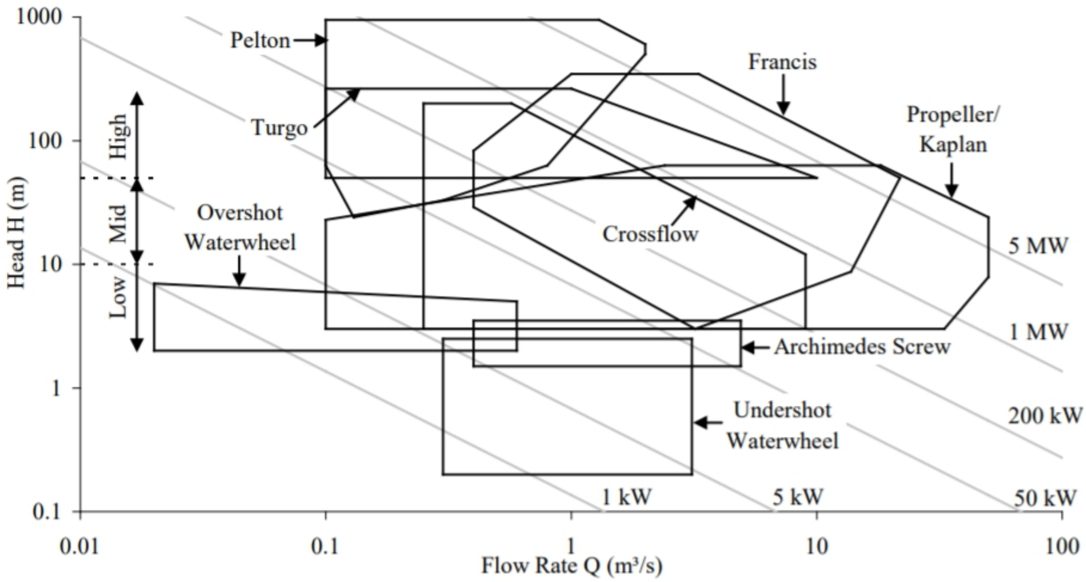


Figure 2.2: Turbine application range chart [32]

As can be seen in Fig. 2.2, the pico range, under 5 kW generation, appears to be sparsely covered by reported application domains. There are several commercially available pico hydro products at high, mid and low head, and these tend to follow the topology of the larger scale turbines. The use of traditional 4 or 6-pole generators and direct generator-grid interfaces restricts the application domains for pico hydro turbines. However, introducing technologies such as low speed generators or inverter-based grid interfaces generally extends a turbine's application domain, thus providing alternative turbine solutions. In addition, the requirements on a pico hydro turbine tend to be different to those of a larger scale turbine; pico hydro generators cannot carry the cost of unique designs for each location, requiring instead off-the-shelf solutions. It can be located in remote locations, several hours walk from the nearest road and have no skilled labour locally to operate and maintain the system. The application domain selection method of turbine selection does not take these more qualitative factors into account. The method proposed in this paper is used to select a pico hydro turbine for a low head specification using both quantitative and qualitative criteria. [27]

2.4 Classification of Turbines

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. 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. Selection of turbine to be used is very important in the design and development of a pico hydropower system. Figure 2.3 shows the groups of impulse and reaction turbines that are available (M.S. Yahaya, 2009). In general, reaction turbine is 15 fully immersed in water and is enclosed in a pressure casing. The runner or rotating element and casing are carefully engineered so that the clearance between them is minimized. In contrast, impulse turbine can operate in air and works with high-speed jet of water. Usually, impulse turbines are cheaper than reaction turbines because no specialist pressure casing and no carefully engineered clearance are needed. [34]

Table 2.3: Groups of Impulse and Reaction Turbine

Turbine Runner	Head Pressure		
	High	Medium	Low
Impulse	Pelton Turgo Multi-jet Pelton	Crossflow Turgo Multi-jet Pelton	Crossflow
Reaction		Francis Pump-as-turbine	Propeller Kaplan

There are two group of turbines which are impulse turbine and reaction turbine. 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 of water, and the water remains at atmospheric pressure before and after contacting the runner blades. Based on its operating principle, impulse turbine is fit with the proposed pico-hydro system as the hydro power is in the jet of water. It has been highlighted that Pelton turbine is commonly used in a small scale hydropower system particularly in pico-hydro system due to its suitability.[29] One of convenient methods for selecting a turbine for particular hydro system is given in Figure 2.4. The turbine type is selected based on the speed range and power capacity of alternator to be used. It can be noticed in the figure that Pelton turbine is a quite universal turbine. It is not always restricted to high 16 head, but if the power transmitted is low, then the Pelton will also run on low heads, although at slow rotational speed. In the proposed pico-hydropower system, a small scale of Pelton turbine is used. [29]

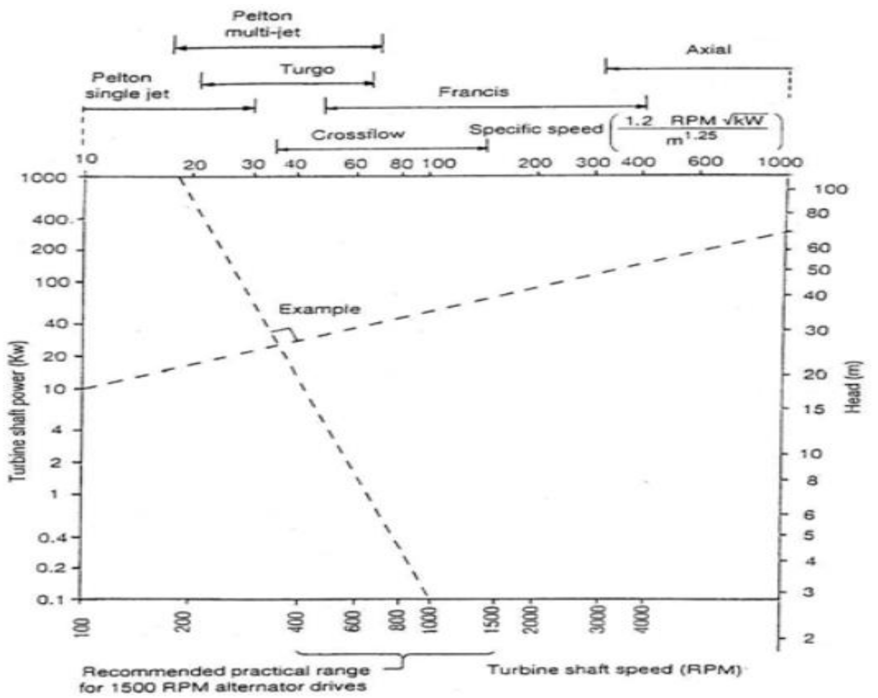


Figure 2.4: Nomogram for selection of a turbine for a hydro site

2.5 How Small Scale Hydro Power Work

All hydropower systems use the energy in flowing water to produce electricity or mechanical energy. In small-scale hydropower, run-of-the-water tank house systems, which do not require large storage reservoirs, are often used. For run-of-the-water tank house systems, a portion of the water is diverted to a water conveyance, such as a channel or pipeline, which delivers the water to a waterwheel or turbine. The moving water rotates the wheel, which spins a shaft. The motion of the shaft produces electricity, which can then be used directly or fed into the grid. [31]

2.6 Affordability

Compared with solar, wind, hybrid, or other fossil fuel-based processes, the PHP scheme is considered the most economic sources of electricity/power. These are some key factors that make the PHP scheme more favorable: (a) Lower capital and construction cost, recent PHP technology advancements have offfffered highly-effiffifficient turbines which have longer life span (e.g. 15–20 years) and reasonable price [16,28,37,38] for low income people. (b) Short payback period, if a high-quality PHP turbine installed and the PHP is well managed. In consequence, many low-income families will be convinced to use PHP [36,39]. (c) Lower operation, replacement, and maintenance costs. PHP is a none-fuel scheme and PHP does not need a battery as in PV or wind [16,48,76]. Maintenance work are not complicated, they can be done by PHP owners by using available local PHP materials and technologies [38]. Furthermore, the entire sub-stitute fee of the PHP turbine is almost same as the budget of purchasing new one [16,28,36]. (d) Low electricity/power cost, over other renewable energy processes, the PHP scheme has the lowest tariffff with

USb10/kW h to USb1020/kW h [16,81], that is 15% less than of that of the PV (a home solar electric/power system). [35,40]

2.7 Theory of Turbine

In this section, we will discuss about the working principle and design of the Pelton turbine and Turgo turbine. There are many number of different hydroelectric turbine designs, but they all incorporate the simple principle of converting the potential energy stored in water into mechanical energy by using a portion of it to rotate a paddlewheel or propeller-type runner on the turbine.

2.7.1 Pelton Turbine

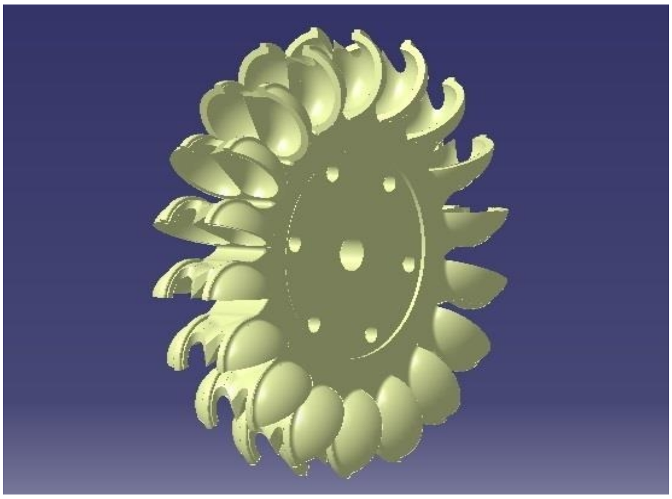


Figure 2.5: Design of the Pelton turbine

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. [28] 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 coming 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.[28]

2.7.2 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.

2.8 Penstock Pipe

Penstock pipe plays an important role in the development of pico-hydro system whereas its purpose is to move the high pressure water to rotate the turbine. Penstock pressure rating is critical because the pipe walls must be thick enough to withstand the maximum water pressure to avoid the risk of bursting pipe. This is because the pressure of the water in the penstock depends on the head where the higher the head, the higher the pressure. [18]

The efficiency of the penstock depends on the material, length and diameter of the pipe. If large diameter pipeline, the less friction occurs and more power can be delivered to the turbine but the cost will be more expensive. In this case, the flow rate of water is calculated by using bucket method with the equation below:

$$Flow\ rate = \frac{Bucket\ Volume}{Time\ to\ fill\ the\ bucket}$$ ....[equation 1]

2.9 Types of Electrical Load

Electrical loads that are normally connected to a pico-hydro system at rural area are lighting, battery chargers, radios, televisions, ventilation fans and refrigerators. [29] The main function of the proposed system is for battery charging. A battery allows the future use of small electrical loads and can be recharged when required. Examples of future use of small loads particularly during electricity blackout are LED lighting, mobile phone battery charging and toys battery charging.

There are two common types of rechargeable batteries used for providing power to small loads which are lead-acid and nickel-cadmium (Ni-Cad). Battery size depends on the generating capacity of the proposed pico hydro system and its applications. For this type of pico hydro system, Ni-Cad battery is preferred and more practical as it is easier to handle and reliable. Moreover, Ni-Cad is the opposite to lead acid in that it performs 25 better and last longer if fully discharged before re-charging. On the order hand, lead acid batteries should not fully discharge as this damages them.

2.10 Battery Charger

The generator output is connected to the charging circuits for energy storage purpose. Simple charging circuit as shown in Figure 2.6 is used. The battery charger is suitable for 9V to 12V batteries. For charging purpose, the maximum load current is limited to 1.5A. This is based on the maximum load current of the LM317 voltage regulator and the maximum current at continuous duty of the generator. In addition, due to the generating capacity of the pico-hydro system, Ni-Cad battery is preferred. [29]

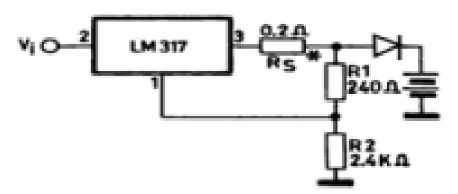


Figure 2.6: Simple battery charger using LM317 voltage regulator

2.11 Power Estimation

In theoretical, the amount of output power produced by pico-hydro system is depends on the flow rate of water (Q), the gravity (g), water flow head and the efficiency of the system (Ş) that presented in the equation. [18]

$P = \eta Q g h$ ....[equation 2]

Where power is measure in watts, water flow rate is measure in l/s and gravity value is $9.81 m/s^2$ Normally, the efficiency is assumed 50% due to losses in penstock pipe, turbine and generator. [18]

2.12 Time of generation

In the residential building like flat the maximum consumption of water will be high during the morning time from 05.00 am up to 10.00 am. In this time duration almost all the people will be using one or more sources of water for cooking bathing or laundry needs. At this period of time we obtain the maximum flow rate since continuous consumption of water is occurring. The water tank should be filled up every day before the starting of consumption time both at head and water pressure will be maintained. [18]

2.13 Volume of water tank

Initially we should consider a residential building like flats, villas where large number of people are thickly populated at a small area. The volume of water tank, which is installed in the residential building in the first place will have high capacity. As the volume increases then the maximum flow rate is obtained. [29]

2.14 Broad nozzle pipe end

The normal flow rate in pipe could be increased by using a nozzle. A new design is adopted for nozzle the nozzle to enable effective generation of power. The pipe is made changed to an oval nozzle with very narrow mouth, which pushes out the water as a line to a large area.

The nozzle is been designed especially for the Pelton and Turgo turbine, so a linear opening for the mouth is been advised for the nozzle. After passing through the turbine area the pipe again converges back to the normal position allowing uninterrupted water flow. With a distance that could regain the head and flow rate for working of another turbine. [18]

2.15 DC Generator

A permanent magnet DC generator is preferred for generating electricity out of the mechanical power produced in a pico-hydro system. DC generator could provide high currents at even minimum voltage required for changing of the battery and operation of direct current loads. They are much cheaper and are small in size too. In this type of generator the efficiency is considered to be more since no power is wasted to generate magnetic field. [22]

2.16 Pulley System

Pulley system is a method to change the speed of turbine. It consists of belt connected to two pulley wheels that called driver and driven each on a shaft. Furthermore, the speed of pulley wheel depends on the size of the wheel. The smaller wheel will spin faster than the larger wheel. The pulley wheels for this project with diameter 0.12m and 0.06m. The output speed of this system is calculated using formula. [19]

$$\text{Output speed} = \frac{input\ speed}{\left(\frac{diameter\ of\ driven}{diameter\ of\ driver}\right)}$$ ……………[equation 3]

2.17 Battery charger

Batteries are used for storing of electrical energy and reused when necessary. The generator output is made connected to the charging circuits for energy storage. When charged a maximum load current is limited to 1.5 A, Ni-Cad battery is preferred for the picohydro system. Lead acid battery could be also used if necessary. [22]

2.18 Arduino

Figure 2.10: Arduino IDE

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino and Genuino hardware to upload programs and communicate with them. Support for thirdparty hardware can be added to the hardware directory of your sketchbook directory. Platforms installed there may include board definitions (which appear in the board menu), core libraries, bootloaders, and programmer definitions.

2.19 Proteus Simulator

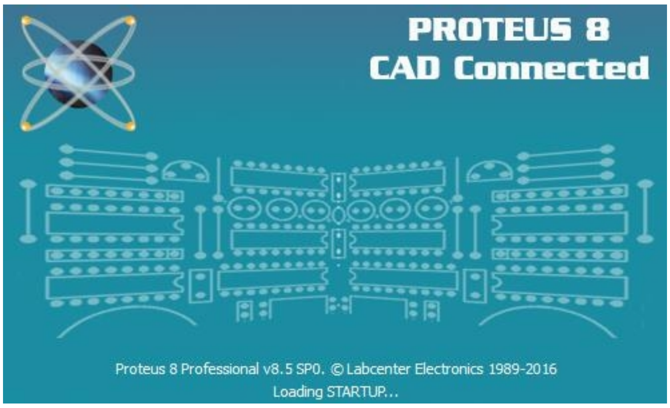


Figure 2.11 : Proteus 8 Software

The Proteus Design Suite is a Windows application for schematic capture, simulation, and PCB layout design. The suite combines mixed mode SPICE circuit simulation, animated components and microprocessor models to facilitate co-simulation of complete micro-controller base designs. Proteus has also the ability to simulate the interaction between software running on a microcontroller and any analogue or digital electronics connected to it. It simulates Input / Output ports, interrupts, timers, USARTs and all other peripherals present on each supported processor.

2.20 Arduino UNO Board

Figure 2.12: Arduino Uno Board

The operating voltage is 5V. The recommended input voltage will range from 7v to 12V. The input voltage ranges from 6v to 20V. Digital input/output pins are 14 Analog i/p pins are 6. DC Current for each input/output pin is 40 mA. DC Current for 3.3V Pin is 50 mA. Flash Memory is 32 KB. SRAM is 2 KB. EEPROM is 1 KB. CLK Speed is 16 MH.

The Arduino Uno power supply can be done with the help of a USB cable or an external power supply. The external power supplies mainly include AC to DC adapter otherwise a battery. The adapter can be connected to the Arduino Uno by plugging into the power jack of the Arduino board. Similarly, the battery leads can be connected to the Vin pin and the GND pin of the POWER connector. The suggested voltage range will be 7 volts to 12 volts.

Pin1 (TX) & Pin0 (RX) (Serial): This pin is used to transmit & receive TTL serial data, and these are connected to the ATmega8U2 USB to TTL Serial chip equivalent pins.

Pin 2 & Pin 3 (External Interrupts): External pins can be connected to activate an interrupt over a low value, change in value.

Pins 3, 5, 6, 9, 10, & 11 (PWM): This pin gives 8-bit PWM o/p by the function of analogWrite().

SPI Pins (Pin-10 (SS), Pin-11 (MOSI), Pin-12 (MISO), Pin-13 (SCK): These pins maintain SPI-communication, even though offered by the fundamental hardware, is not presently included within the Arduino language.

Pin-13(LED): The inbuilt LED can be connected to pin-13 (digital pin). As the HIGHvalue pin, the light emitting diode is activated, whenever the pin is LOW.

Pin-4 (SDA) & Pin-5 (SCL) (I2C): It supports TWI-communication with the help of the Wire library.

AREF (Reference Voltage): The reference voltage is for the analog i/ps with analogReference().

Reset Pin: This pin is used for reset (RST) the microcontroller.

Memory

The memory of this Atmega328 Arduino microcontroller includes flash memory-32 KB for storing code, SRAM-2 KB EEPROM-1 KB

2.21 Clear Acrylic Sheet

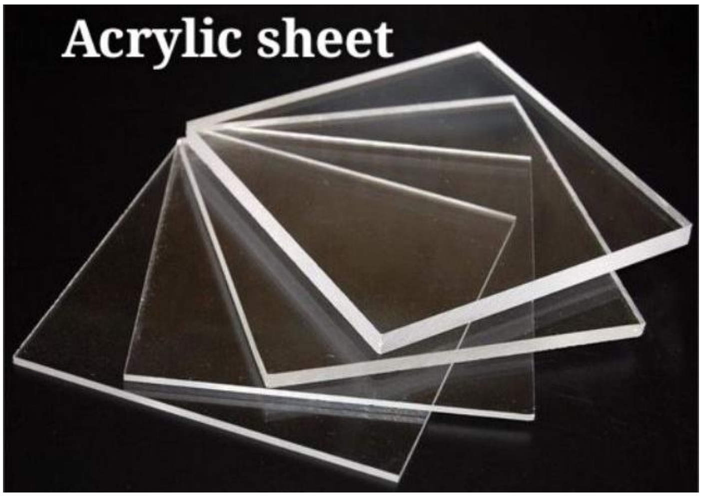


Figure 2.14: Acrylic Sheet

In this design, we used the acrylic sheet as a casing of the product. This is because we can easily to know what is happened to the turbine.

Size: 297mm x 420mm(A3)

Thickness: 10mm

2.22 Brushless DC Motors

Figure 2.15 : Brushless DC Motor

A motor converts supplied electrical energy into mechanical energy. Various types of motors are in common use. Among these, brushless DC motors (BLDC) feature high efficiency and excellent controllability, and are widely used in many applications. The BLDC motor has power-saving advantages relative to other motor types.

2.23 Solenoid Valve

Figure 2.16 : Solenoid Valve DC 12V

A solenoid valve is an electrically controlled valve. The valve features a solenoid, which is an electric coil with a movable ferromagnetic core (plunger) in its center. In the rest position, the plunger closes off a small orifice. An electric current through the coil creates a magnetic field. The magnetic field exerts an upwards force on the plunger opening the orifice. This is the basic principle that is used to open and close solenoid valves.

2.24 Bearing

Figure 2.17 : Deep Groove Ball Bearing

Deep groove ball bearings are the most widely used bearing type and are particularly versatile. They have low friction and are optimized for low noise and low vibration which enables high rotational speeds. They accommodate radial and axial loads in both directions, are easy to mount, and require less maintenance than other bearing types. A bearing with an inside diameter 20mm had been used to make sure that the turbine is rotating the DC motor to generate power.

2.25 3D-Printer Filament

Figure 2.18 : Polycarbonate 3D Printer Filament

3D Printer Filament commonly known as PLA, is one of the most popular materials used in desktop 3D printing. It is the default filament of choice for most extrusion-based 3D printers because it can be printed at a low temperature and does not require a heated bed. Polycarbonate. According to multiple manufacturers and reviewers, polycarbonate (PC) is considered the strongest filament out there. In particular, PC can yield extremely high-strength parts when printed correctly with an all-metal hot end and an enclosure.

CHAPTER 3

METHODOLOGY

3.0 Project Phases

The overall project implementation and completion is expected for 28 weeks. According to the course timeline which is divided for Final Year Project I and II, each phase for the realization of project is taken into consideration.

3.0.1 First Phases

For the first phase occurring in the initial 14 weeks, the inception and conceptual stage takes place. Within this phase, several researches will be reviewed which deemed appropriate for the project as well as identifying the problem statement for current objectives. Next, some literature reviews had made to find related projects and the idea of the system and design. In the modelling phase, we set up the implementation of the system in the water tank. Afterwards, measurement and data gathering will be starting at the control site and this may include the dimension of the water channel (m), flow rate (m^3/s) and also velocity of water (m/s). From hand sketches to using Solidworks software, the overall design of the components for the system are modelled in 3D. Moreover, the circuit design had done in protues software. In the testing phase, we had repeated to test it and modified the design to get a better result.

3.0.2 Second Phase

The second phase of the project commences at the final 14 weeks of the course timeline. This phase involves the implementation and analyse stage. The fabrication will involves manual labour in terms of metalworking processes such as welding, bending and lathing. 3D Printer Kits have been used to produce turbines that have been designed in FYP 1. Figure 2.19 show example design done in FYP 1. Moreover, the circuit design had done in tinkercad circuit design. After fabrication, site testing will proceed with the produced system model. Several measurements will be taken on site such as power output from the turbine (W), torque produced (rpm) as well as velocity of water flow and jet flow (m/s) which are important to study the effect of this parameters on voltage output performance.

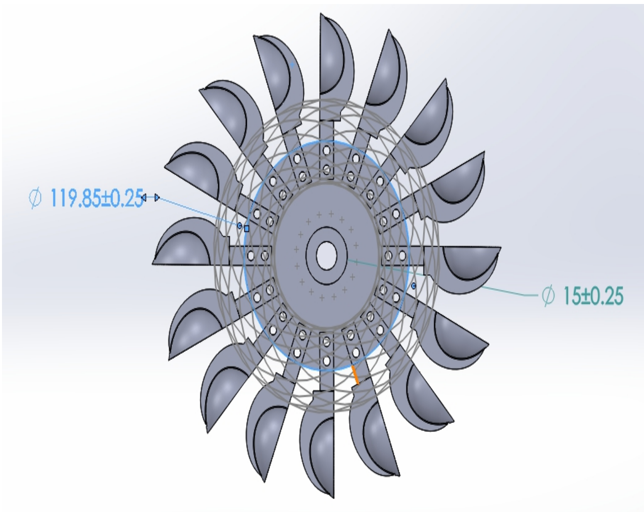


Figure 2.19 : Pelton Turbine

3.0.3 Flow Chart of Methodology

The flowchart of the system shown in Figure 2.20. First of all, we identify the problem of the project. Next, some literature reviews had made to find related projects and the idea of the system and design. In the modelling phase, we set up the implementation of the system in the water tank. Moreover, the design had sketched in solidworks and the circuit design had done in tinkercad circuit design. In the testing phase, we had repeated to test it and modified the design to get a better result.

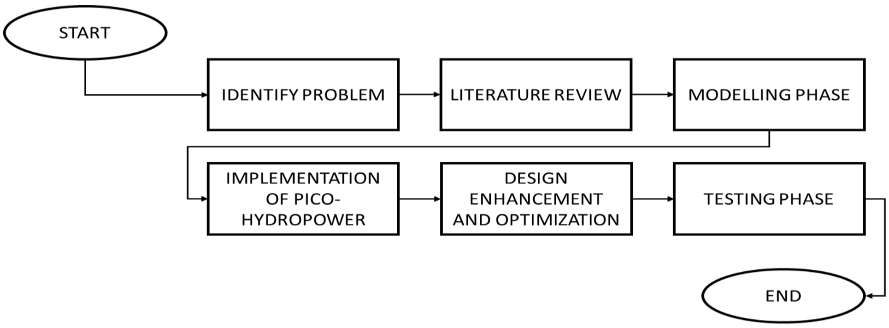
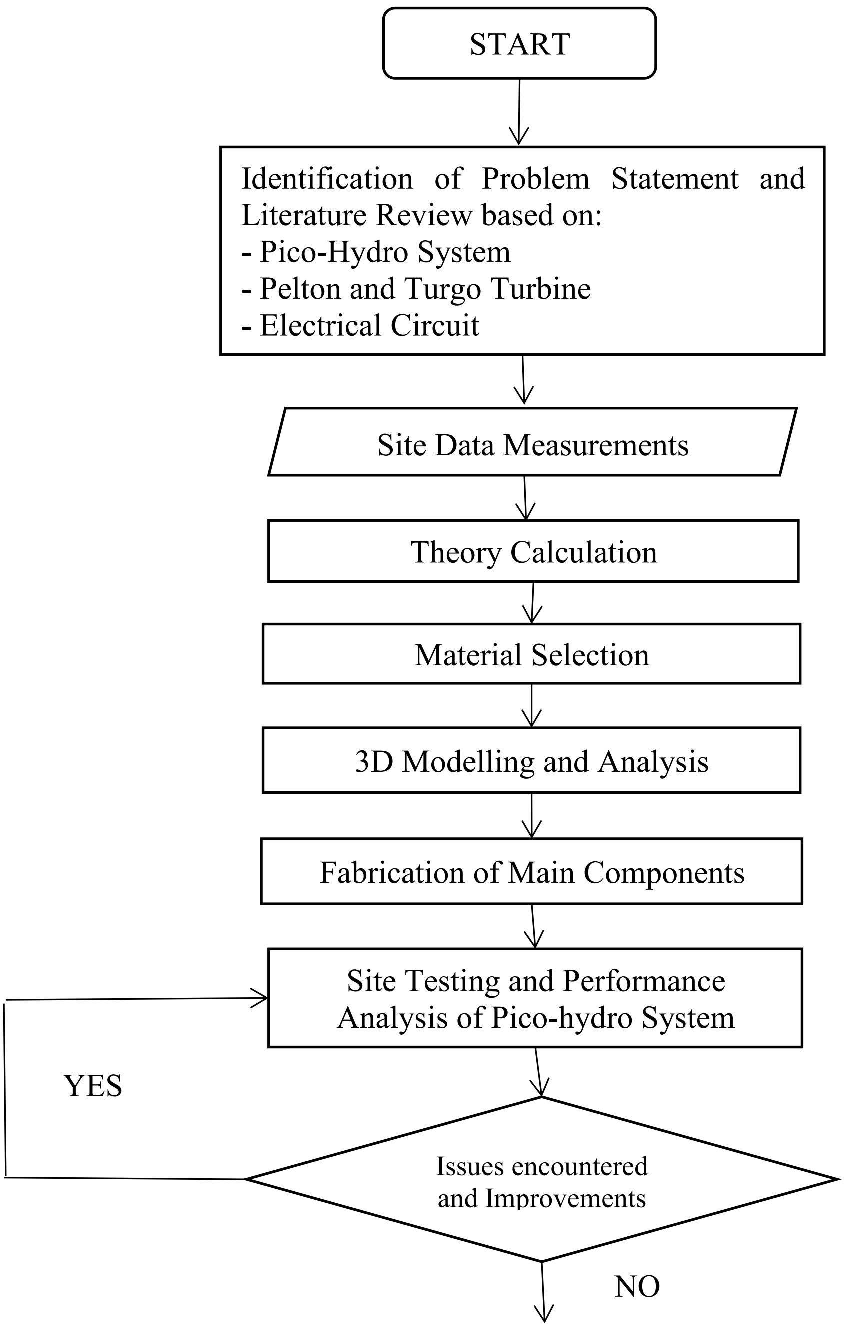
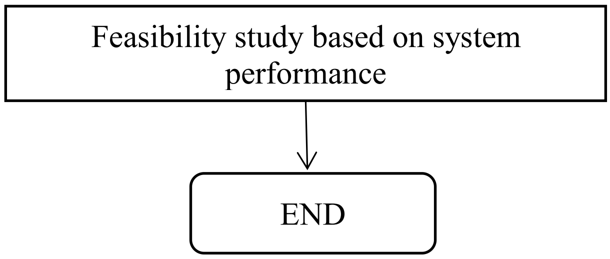


Figure 2.20 : Flowchart of Methodology

3.1 Project Flowchart





3.2 Project Activities

3.2.1 Fabrication of Hydro System Components

1. Fabrication of Basement Pico-Hydro Turbine

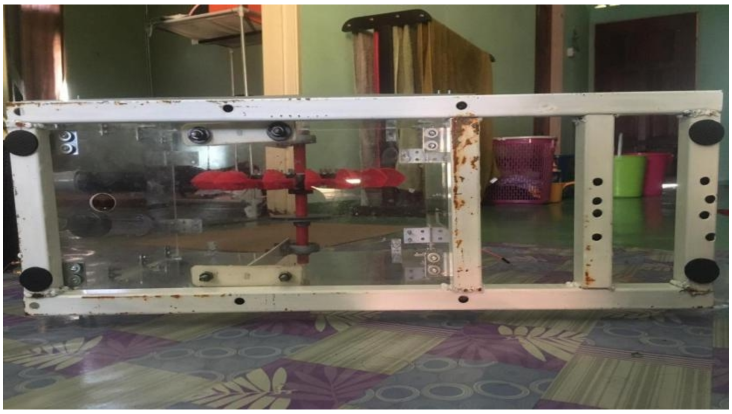


Figure 3.1 : Basement Project

The basement is modelled based on design done through Solidworks software. The dimension and shape of the basement is based on the water tank in houses. Fabrication of basement project continues until 2 weeks. The material which is used is Metal with varying thickness (2mm - 3mm).

2. Casing Project

Figure 3.2 : Fabrication of Casing Project

The casing is done based on the size of the turbine and generator itself. The construction of the casing took approximately 6 weeks due to various issues encountered. The main structure is fabricated using Perspex while screw is used as items to connect perspex

3. Fabrication of Turbines

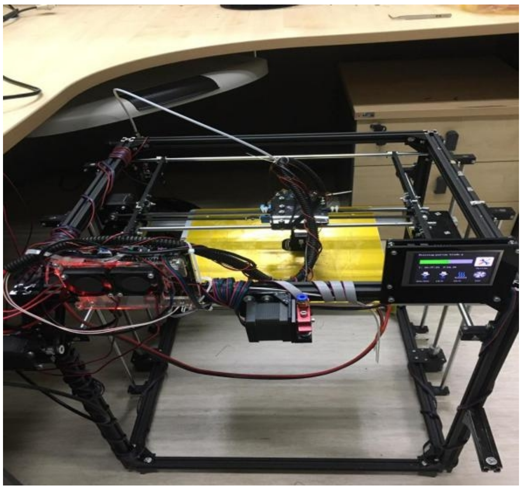


Figure 3.3 : 3D Printer used to print turbine

Figure 3.4 : 16 Blades Pelton Turbine

3D Printers have been used to produce several of the turbines needed in this project. Among the turbines that have been produced is Pelton 16 Blades, Pelton 8 Blades and Turgo Turbines.

3.3.2 Site Testing & Performance Evaluation

1. Testing using Pipe Water

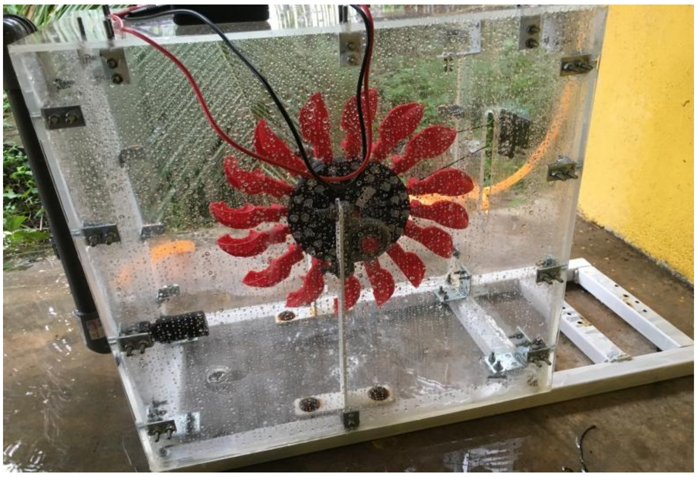


Figure 3.5 : Testing the Hydropower using Black Pipe

The pipe allows full control of water velocity to jet water push the turbines. It assessed in which velocity of water the turbine starts to rotate at full rotation. Measurements are taken using multimeter for voltage & current. The speed of turbines also measurement are taken using tachometer. The data is recorded and analysed as intended. 5 different readings are taken for the following site.

3.4 Selected Model for Hydro System

The major equipments which have been used in the hydro system include:

1. Pelton Turbine
2. Wind Turbine based Generator
3. Mechanical Coupling

Model Specifications:

Pelton Turbine

- Turbine Runner Diameter: 120mm / 0.12m
- Turbine Blades: 16
- Blades Radius: 90mm / 0.09m

Pelton Turbine

- Turbine Runner Diameter : 120mm / 0.12m
- Turbine Blades : 8
- Blades Radius : 90mm / 0.09m

Turgo Turbine

- Turbine Runner Diameter : 120mm / 0.12m
- Turbine Blades : 16
- Blades Radius : 90mm / 0.09m

DC Motor

- Model: Brushless DC Motor
- Rated Power: 30 W
- Rated DC Voltage: 12VDC
- Rated Current: 2-3.7A
- No Load Rated Speed: 3000 rpm

Figure 3.6 : 8 Blade Pelton

Figure 3.7 : 16 Blade Pelton

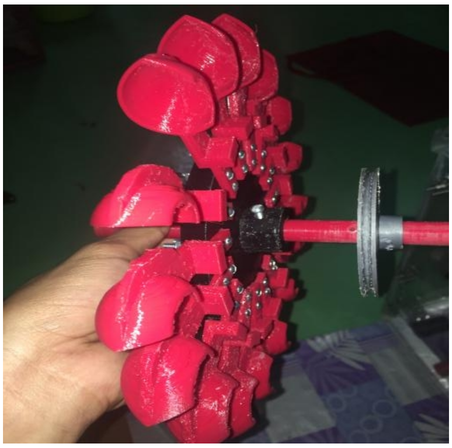


Figure 3.8 : Turgo Turbine

Figure 3.9 : Full Image of Pico-Hydropower

CHAPTER 4

RESULT AND DISCUSSION

4.0 Theoretical Calculation for Pelton Turbines

Power, Efficiency and Specific Speed Expressions:

From Newton's second law applied to angular motion,

Angular momentum = (Mass)(Tangential velocity)(Radius)
Torque = Rate of change of angular momentum
Power = (Torque)(Angular velocity)

Considering the water jet striking the runner generates a torque of T and rotates the runner with N (rev/m), then power obtained from the runner can be expressed as:

$$P_{out} = T\omega \quad \text{......[equation 4]}$$

$$T = \frac{P_{out}}{\omega} \quad \text{......[equation 5]}$$

$$= \frac{0.6309\ W}{39.24}$$

$= 0.01608$ N/m

$$\omega = \frac{2\pi N}{60}$$

$$= \frac{2\pi(277 rpm)}{60}$$

$= 29.01$ rad/s

The total head available at the nozzle is equal to gross head less losses in the pipeline leading to the nozzle (in the penstock) and denoted by H . Then available power input to the turbine becomes:

$$Pin = \rho g Q H \text{ ......[equation 6]}$$

= (997 kg/m^3) x (9.81 m/s^2) x (0.00005556m^3/s) x (3m)
= 1.6302 W

$$P_{out} = T\omega \text{ ……[equation 7]}$$

= (0.01608 N/m) x (29.01 rad/s)
= 0.4665 W

Where:

Pin = Power input to turbine
H = Total available head [m]
ρ = *density of water [kg/m3]*
Q = volume flow rate of water [m3 /s]
g = gravitational acceleration [m/s2]

For a turbine:

Considering all losses as one term:

$P_{in} = P_{lost} + P_{out}$
$P_{lost} = P_{in} - P_{out}$ ……..[equation 8]

= 1.6302 W - 0.4665 W
= 1.1637 W

Then, overall efficiency of turbine becomes:

$$\eta_o = \frac{P_{out}}{P_{in}} = \frac{T\omega}{\rho g Q H}$$ ……..[equation 9]

$$= \frac{0.4665\ W}{1.6302\ W}$$

$$= 0.2862$$

Pelton wheel is directly coupled to a generator to produce electricity. Therefore, another efficiency term, namely generator efficiency is used to show how efficiently the mechanical energy is converted to electricity.

$$\eta_{gen} = \frac{P_e}{P_{out}} = \frac{VI}{T\omega}$$ ……[equation 10]

$$= \frac{(5.89\ V)\ x\ (90\ mA)}{0.6309\ W}$$

$$= 0.8402$$

4.1 Design of Pico Hydropower system Components

4.1.1 Design of Casing Project

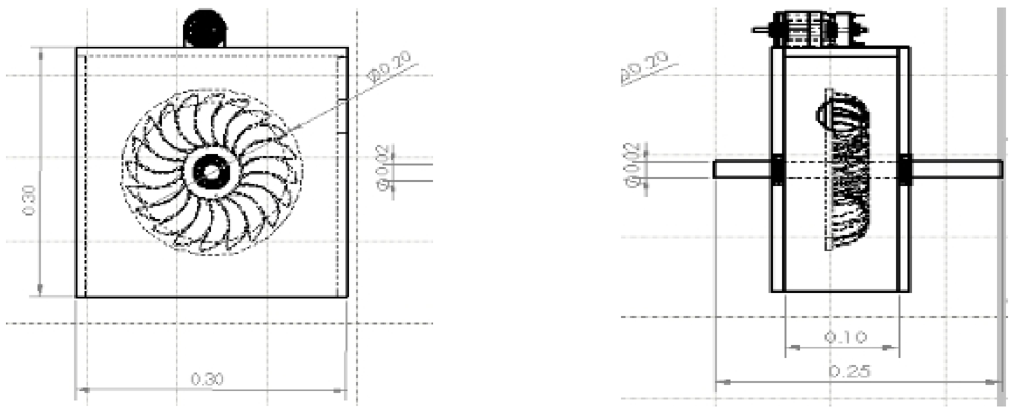


Figure 4.0 : Casing design and dimension project

The casing project have design by review the overall dimension of tubines. Before making this design, measurements have been made so that the turbine, motor and pipes can fit in this casing. Casing holes should be made for water release in this casing and also water does not stagnate in the casing. Holes for rods and motors also should be taken for this design casing.

4.1.2 Design of Pelton Turbines

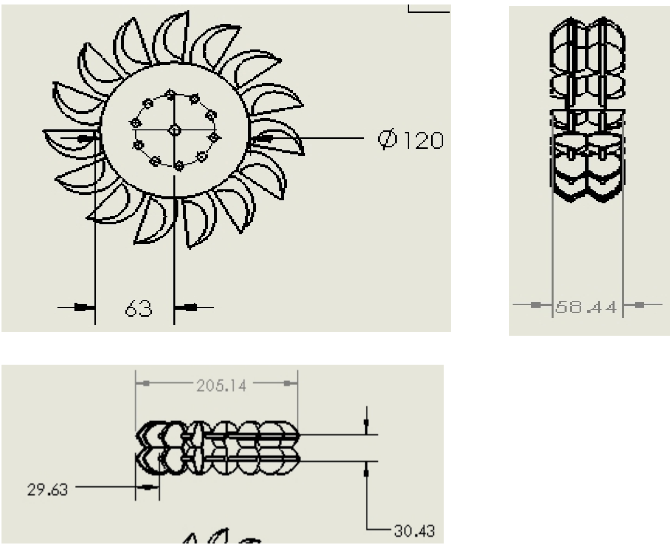


Figure 4.1 : Design of Pelton and dimension turbines

For this Pelton turbines design, some references have been made to complete the entire design. Blades and runner turbines has been separated by part for the number of blades turbines can be change. This design also use for 8 blades pelton turbine.

4.1.3 Design of Turgo Turbines

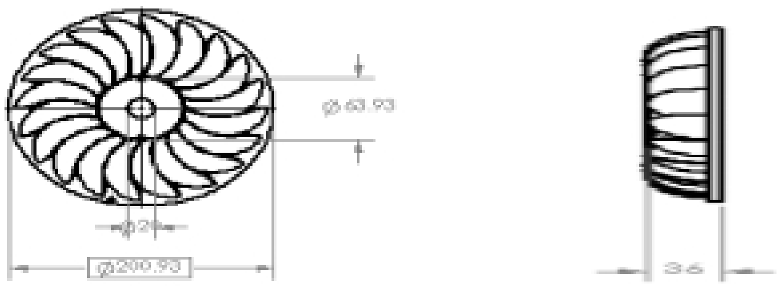


Figure 4.2 : Design of Turgo and dimension turbines

This is the first design have been done for Turgo turbine. Improvement have been made to this design because the design is not suitable on the project flow needed. For the second design, blade or bucket from Pelton only make one side to make a Turgo blade complete like show in Figure 4.3.

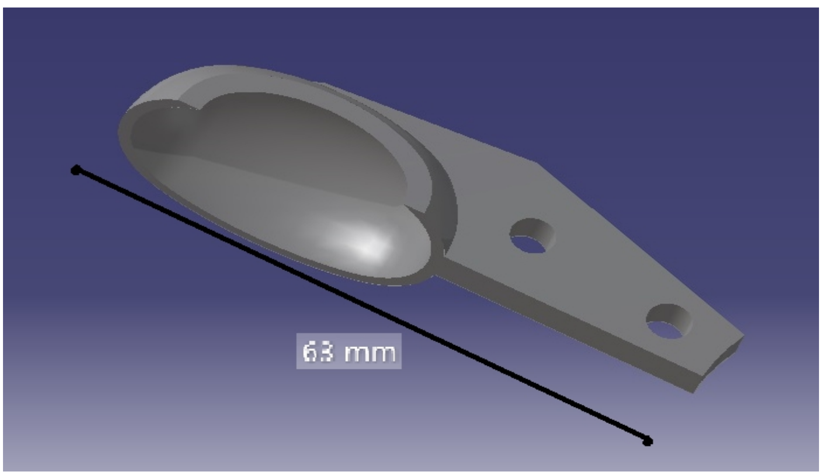


Figure 4.3 : Design Bucket or Blade for Turgo Turbines

4.2 Experiment

4.2.1 Result

Pelton

8 blade

Table 4.0 : Results Red Pipe and 8 blades Pelton

Pipe colour	Flow rate	Rpm blade	Rpm motor	Vout	Current (mA)	Power (mW) =IV
Red	100	9.3	32.0	0.27	0.0	0
Red	150	28.4	271.1	1.06	6.5	6.89
Red	200	74.9	330.6	1.89	12.6	23.81
Red	250	108.7	543.9	2.44	30.0	73.2

Table 4.1 : Results Black Pipe and 8 blades Pelton

Pipe colour	Flow rate	Rpm blade	Rpm motor	Vout	Current (mA)	Power (mW)
Black	100	24.0	125.4	0.89	1.1	0.979
Black	150	70.2	301.9	1.19	9.4	11.19
Black	200	119.8	616.5	3.21	54.9	176.23
Black	250	277.8	1432.1	5.89	90.0	530.1

Table 4.0 and 4.1 show the experiment result for red pipe and black pipe using 8 blades pelton turbine. Using black pipe and 8 blade pelton turbine is the best performance in this project. In this experiment, also show black pipe and 8 blade pelton turbine can produce highest output value for voltage, power and current. In this case, its can produce highest value for value output because using a 8 blade the material become more lighter and project can perform well. Using a red pipe and 8 blade show that the value output not to good if compare with black pipe. It also prove that black is better performance than red pipe.

16 blade

Table 4.2 : Results Red Pipe and 16 blades Pelton

Pipe colour	Flow rate	Rpm blade	Rpm motor	Vout	Current (mA)	Power (mW)

Red	100	7.3	21.0	0.15	0.0	0.0
Red	150	12.7	107.1	0.82	1.1	0.902
Red	200	44.0	289.8	1.01	5.9	5.959
Red	250	71.9	500.6	1.59	8.3	13.197

Table 4.3 : Results Black Pipe and 16 blades Pelton

Pipe colour	Flow rate	Rpm blade	Rpm motor	Vout	Current (mA)	Power (mW)
Black	100	12.9	108.5	0.87	0.9	0.783
Black	150	54.9	299.1	1.18	9.4	11.092
Black	200	107.1	541.7	3.00	47.9	143.7
Black	250	255.8	1335.0	5.35	78.8	421.58

Table 4.2 and 4.3 show result for red pipe and black pipe using 16 blades pelton turbine. For this table show using black pipe is better output than using red pipe. In this experiment also show that using 8 blade pelton turbine is better output value than 16 blade pelton turbine. This also proves for the type of turbine pelton is more suitable use 8 blades because it is more lighter than 16 blades.

Turgo

Table 4.4 : Results Red pipe and Turgo Turbines

Pipe colour	Flow rate	Rpm blade	Rpm motor	Vout	Current (mA)	Power (mW)
Red	100	8.9	30.4	0.19	0.0	0.0
Red	150	21.7	268.4	0.93	0.4	0.372
Red	200	61.2	321.3	1.82	9.8	17.836
Red	250	106.0	532.5	2.29	26.7	61.143

Table 4.5 : Results Black pipe and Turgo Turbines

Pipe colour	Flow rate	Rpm blade	Rpm motor	Vout	Current (mA)	Power (mW)
Black	100	11.5	95.5	0.77	0.3	0.231
Black	150	46.3	263.4	1.09	7.2	7.848
Black	200	106.3	529.0	2.04	20.4	41.616
Black	250	210.5	1300.2	3.21	56.0	179.76

Table 4.4 and 4.5 show result red pipe and black pipe using turgo turbines. From this result, turgo turbine show that using black pipe more suitable in this project. Result also show turgo turbine produces output not good as pelton turbines. Of the 6 table result produce show using black pipe and 8 blade pelton turbines is the best performance in output value.

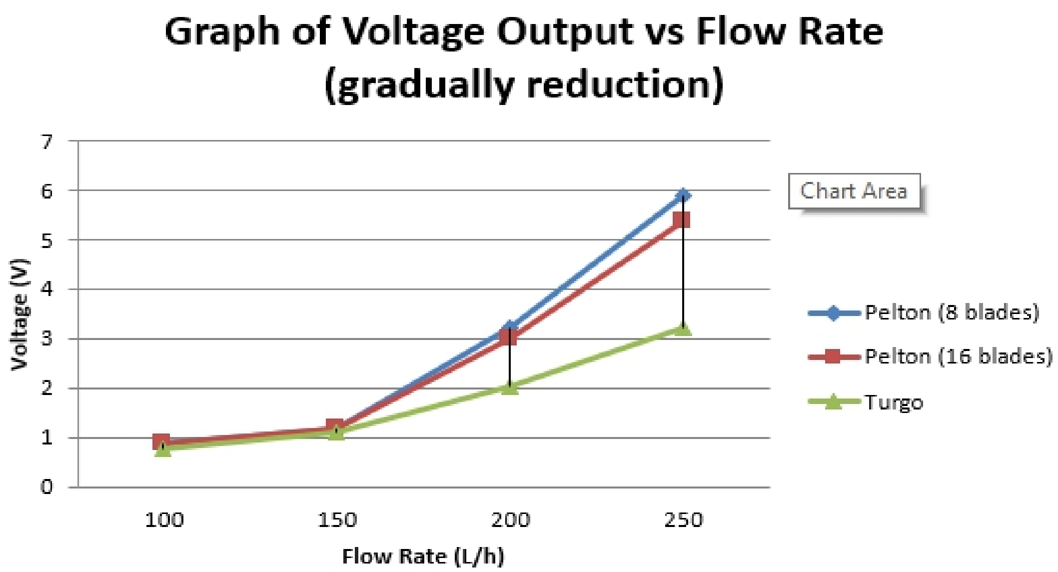


Figure 4.4 : Graph of Voltage Output vs Flow Rate (gradually reduction)

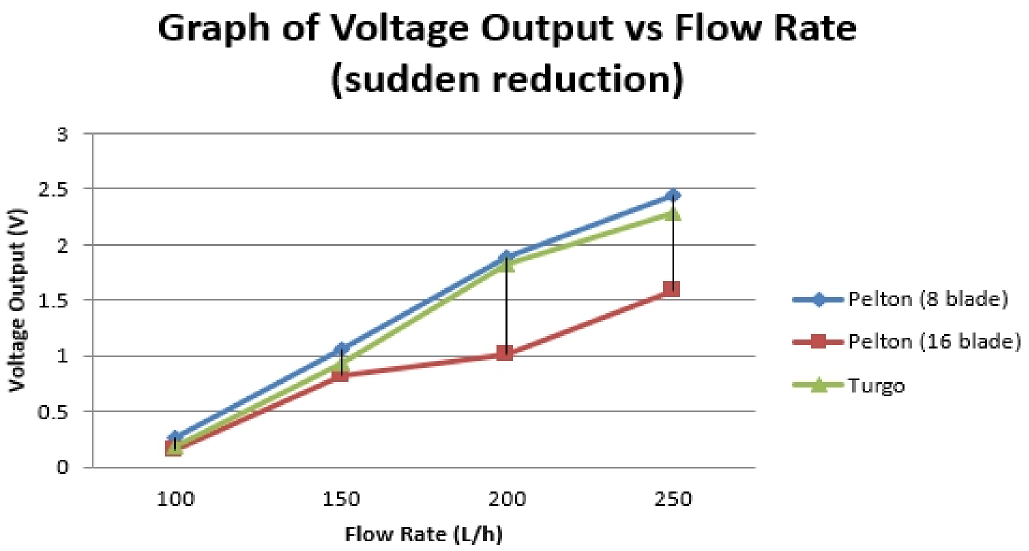


Figure 4.5 : Graph of Voltage Output vs Flow Rate (sudden reduction)

In the graph of Figure 4.4 and Figure 4.5, the maximum output voltage can reach until 5.89V when flowrate reach 250L/h and 8 blades pelton turbine was used.

Table 4.6 Gradually reduction nozzle flowrate vs blade speed

Flowrate (L/h)	Blade speed (rpm)		
	60 degree	40 degree	30 degree
100	24	10	8
150	70.2	30.2	29.5
200	119.8	50.9	35.7
250	277.8	107.5	70.5

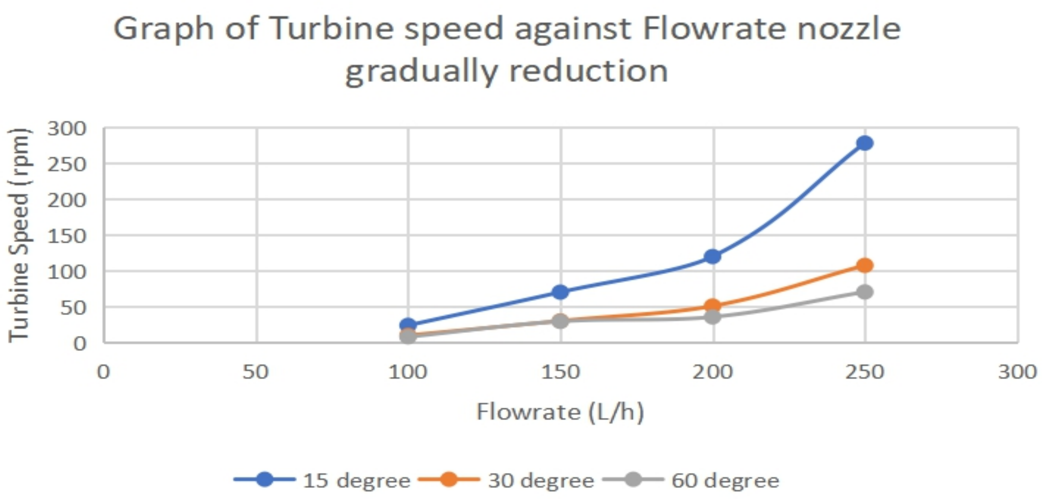


Figure 4.6 Graph of blade speed against Flowrate nozzle gradually reduction (ratio 3)

Table 4.7 Sudden reduction nozzle flowrate vs blade speed

Flowrate (L/h)	Blade speed (rpm)			
	ratio 0.1	ratio 0.25	ratio 0.5	ratio 0.7
100	6.5	17.5	9.3	9
150	15.3	48.4	28.4	24.3
200	15.4	80.5	74.9	71.5
250	15.3	145.7	108.7	72.5

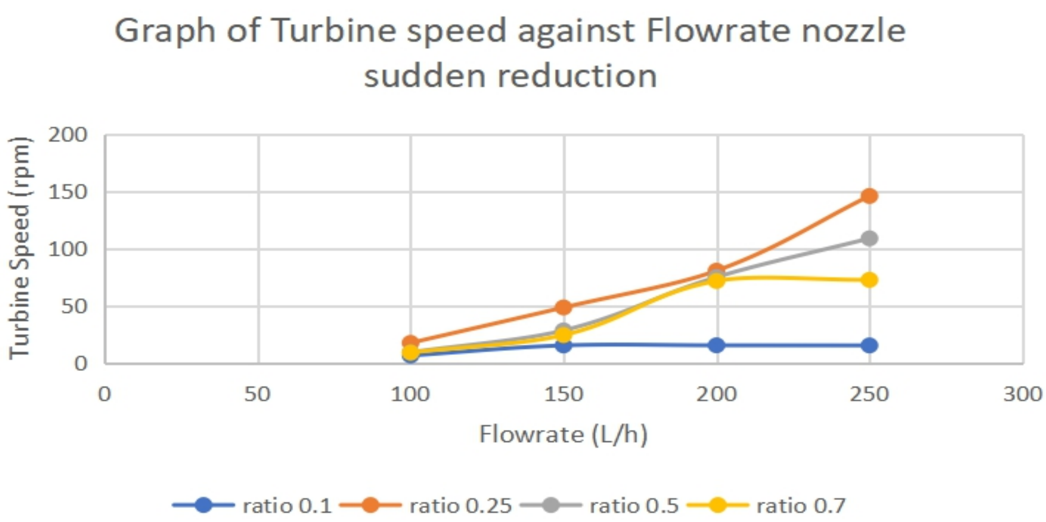


Figure 4.7 Graph of blade speed against Flowrate nozzle sudden reduction

In the experiment of the nozzle, sudden reduction pipe and gradually reduction pipe had been choose due to the efficiency of the pipe is higher than other type of pipe and between these two pipes have an obvious difference. Table 4.6 and Figure 4.6 shown the reading of the gradually reduction nozzle. Based on the graph in Figure 4.6, nozzle with 60° have the best performance in the gradually reduction nozzle. The nozzle can push the turbine rotate until 277.8rpm at flowrate of 250L/h. and the best performance of sudden reduction nozzle is in ratio 0.25. The nozzle in ratio 0.1 and 0.7 change to incline after 200L/h due to the maximum flowrate of nozzle ratio 0.1 is around 160L/h but the nozzle ratio 0.7 it the output hole too large until the velocity of water reach maximum after flowrate 220L/h.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The project mainly focuses on the implementation of pico-hydro system at Water tank houses in order to save on the operating expenses related to power consumption. Several design processes and calculations have been done to assess the feasibility. Based on the theoretical values, the pico hydro system is capable of producing up to

5kW of power. The power produced from operation of Pelton turbine is highly dependent on water source velocity,Vr (m/s). Therefore, the power produced by hydro system may have been higher if the turbine uses a lighter material. In general, the hydro system is implementable at site with varying power output depending on the type of hydraulic turbine used e.g. Impulse or Reaction Turbines. However, based on the feasibility study done and improvements made to the project it is viewed that using Reaction Turbine is not suitable for the Pico Hydropower system as the flow rate is too small due to water source velocity.

5.2 Recommendations

For the future works on this project, several recommendations and improvement are expected that can make the project more feasible and achievable for the pico-hydro system :

a) Proper selection of hydraulic turbine to assess on the performance, where selections are made according to the flow rate and gross head at the site. Selection of the turbine can be made based on the graph available in the book.

b) Choosing a higher specification generator to produce greater capacity of power. Selection of generator can be made by knowing the turbine speed (rpm) through calculations which is relative to power output.

c) Utilizing various components e.g. water pump and control valve to study the effect of water velocity on the turbine performance. As the flow rate at site is too small, using water pump is expected to accommodate the operation of the Impulse Turbine thus producing water stream or jet capable of rotating the machinery.

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APPENDICES

Figure A1 : Measurement for Turbine speed

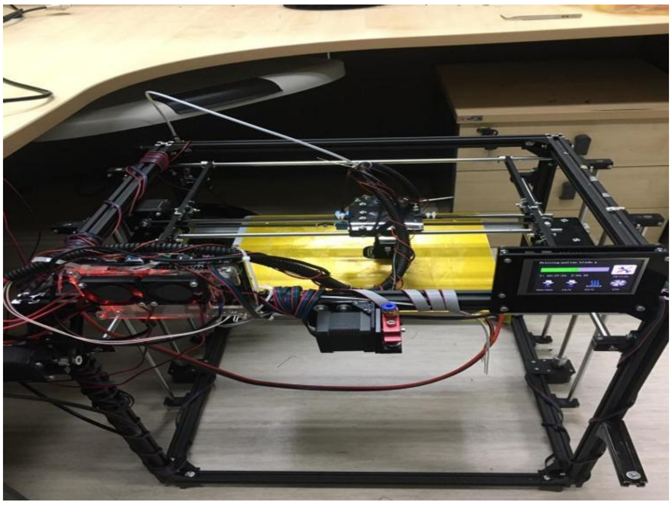


Figure A2 : 3D printer machine used to made turbine

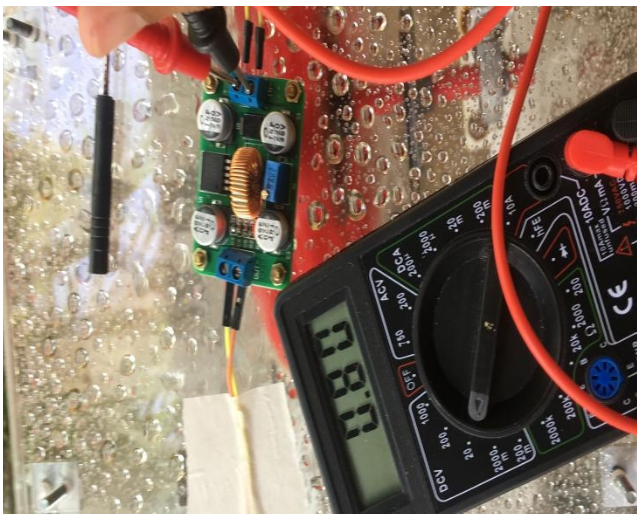


Figure A3 : Measurement for voltage output at step up module

Figure A4 : Casing project still in process

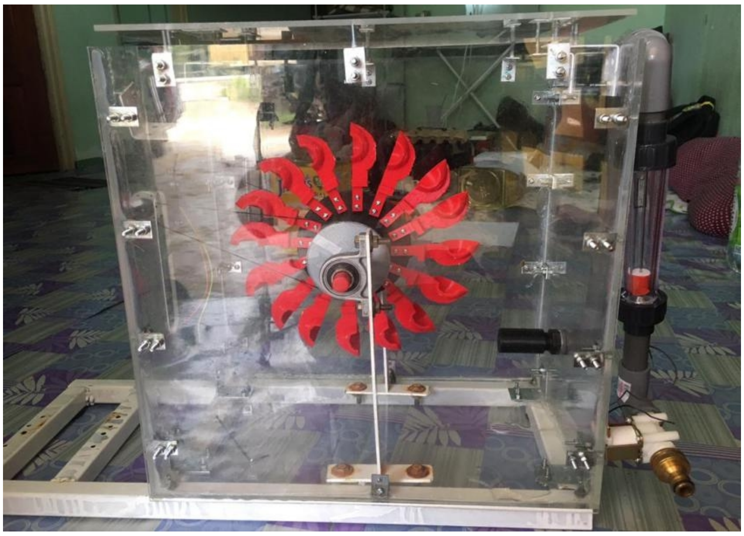
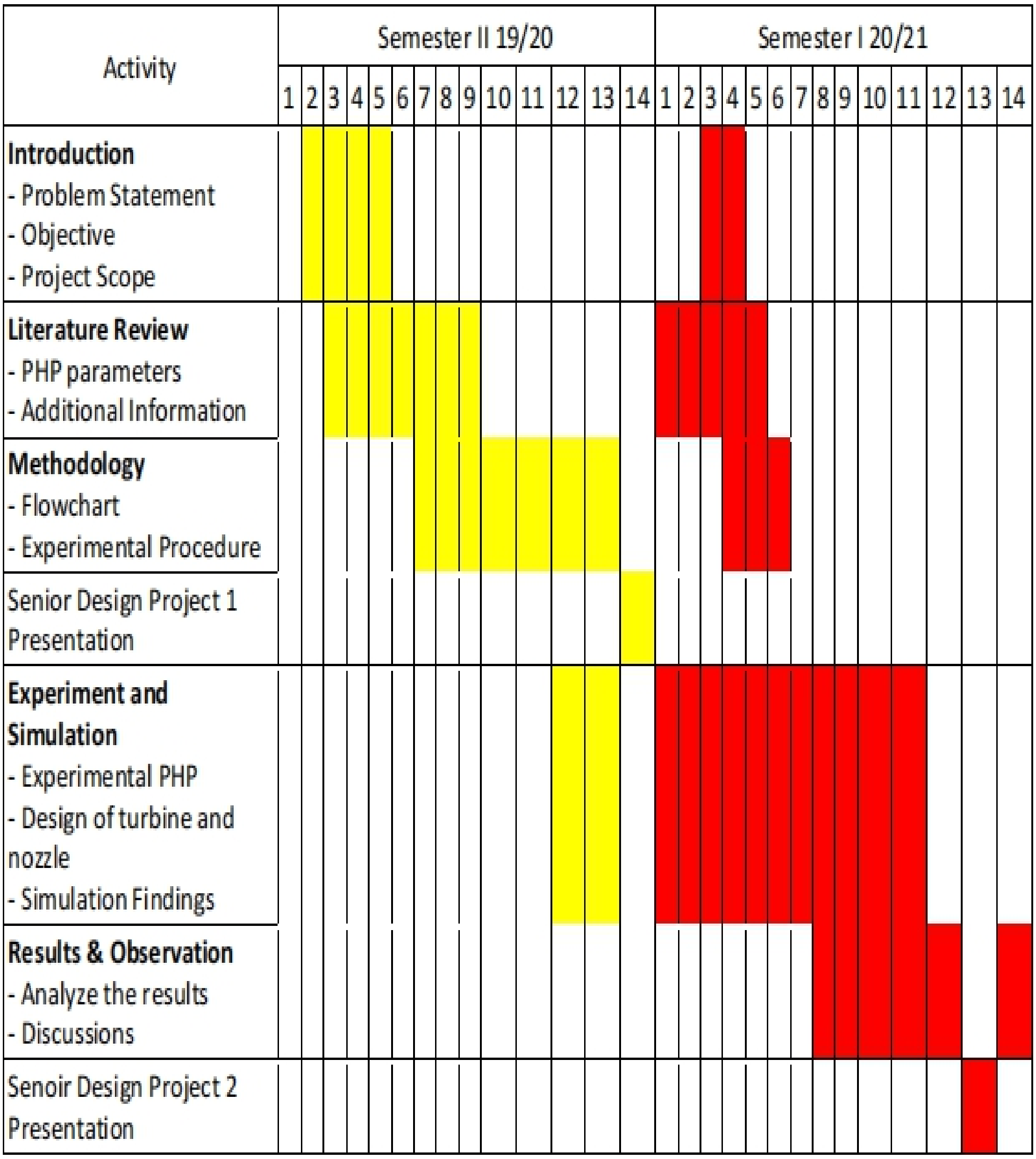


Figure A5 : The whole Pico Hydropower Generator

Appendix A6: Project Cost

NO.	ITEM	QUANTITY	COST/ UNIT (RM)	TOTAL (RM)
1.	Acrylic Sheet A3 size 10mm	2	60.00	120.00
2.	Arduino UNO with casing	1	24.00	24.00
3.	Arduino IoT Water Solenoid Valve	1	25.50	25.50
4.	Brushed DC motor MY1016	1	90.00	90.00
5.	3D-Printer Filament 1kg	1	65.00	65.00
6.	Bearing	2	25.00	50.00
7.	Metal rod D=20mm	1	50.00	50.00
8.	LZS-15 Water Flowmeter	1	75.00	75.00
			TOTAL	RM499.50

Appendix A7 : Project Timeline



Appendix A8 : Arduino Code

```
#include <LiquidCrystal.h>
int level1=A1;
int level2=A2;
int level3=A3;
int level4=A4;
int level5=A5;
int motor=6;
int a;
int b;
int c;
int d;
int e;
int r;
int m=0;
int z=111;
LiquidCrystal lcd(11,12,2,3,4,5);
void setup()
{
pinMode(level1,INPUT);
pinMode(level2,INPUT);
pinMode(level3,INPUT);
pinMode(level4,INPUT);
pinMode(level5,INPUT);
pinMode(motor,OUTPUT);
```

```
lcd.begin(16,2);
}
void loop()
{
r=digitalRead(motor);
a=analogRead(level1);
b=analogRead(level2);
c=analogRead(level3);
d=analogRead(level4);
e=analogRead(level5);
lcd.clear();
lcd.setCursor(0,1);
lcd.print("Easy HM Projects");
lcd.setCursor(0,0);
lcd.print("Water Level Monitor.");
if(e>z && d>z && c>z && b>z && a>z )
{
{
digitalWrite(motor,LOW);
}
lcd.setCursor(0,0);
lcd.print("Tank is 100% FULL");
}
else
{
```

```
if(e<z && d>z && c>z && b>z && a>z )
{
lcd.setCursor(0,0);
lcd.print("Tank is 80% FULL");
}
else
{
if(e<z && d<z && c>z && b>z && a>z )
{
lcd.setCursor(0,0);
lcd.print("Tank is 60% FULL");
}
else
{
if(e<z && d<z && c<z && b>z && a>z )
{
lcd.setCursor(0,0);
lcd.print("Tank is 40% FULL");
}
else
if(e<z && d<z && c<z && b<z && a>z )
{
55lcd.setCursor(0,0);
lcd.print("Tank is 20% FULL");
}
```

```
else
{if(e<z && d<z && c<z && b<z && a<z )
{
{
digitalWrite(motor,HIGH);
}
lcd.setCursor(0,0);
lcd.print("Tank is EMPTY");
}
}}}}
if(r==LOW)
{
lcd.setCursor(0,0);
lcd.print("Water Pump is (OFF)");
}
56else
{
lcd.setCursor(0,0);
lcd.print("Water Pump is (ON)");
}
{
delay(100);
lcd.clear();
}}
```