" I hereby declare that I have read this fully report entitled " *Design and Development of a Low Cost and Portable Pico Hydro Turbine*" and found that it has comply the partial for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

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Supervisor's Name	:	En Zul Hasrizal Bin Bohari
Date	:	1 June 2015

DESIGN AND DEVELOPMENT OF LOW COST AND PORTABLE PICO HYDRO TURBINE

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A report submitted in partial fulfillment of the requirements for the degree of Electrical Engineering (Industrial Power)

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2015

I declare that this report entitled "*Design and Development of a Low Cost and Portable Pico Hydro Turbine*" is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	…….
Name	:	Syahrunizzam Bin Hassin
Date	:	1 June 2015

To my beloved mother and father

ACKNOWLEDGEMENT

Firstly, my biggest thanks to Allah S.W.T who gave me the opportunity in doing this project and always giving me hope and ways in completing the tasks.

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ABSTRACT

The goal of this research is to design, develop and analysis of a low cost and portable Pico hydro turbine. Hydro turbine has become an interest as it widely used around the world, especially in the rural area in Malaysia. The main reason why the hydro turbine is so widely used is due to their renewable source of producing electrical energy which is water. The focus on this project is to develop a portable Pico hydro that can be installed anywhere especially in the house. The project will involve two main phases: the designing of the turbine and the analysis of the turbine using different shape of pipe on the incoming water source. The designed turbine should be capable to meet performance specification for hydropower generation, such as an adequate minimum rate of flow and the type of turbine design used. The power supplied by falling water is the rate at which its deliver energy and this depends on the mass flow rate of the water, which can be manipulated by designing a different shape of pipe at the input water source. To meet the requirement, some issue needs to be considered in designing such as selection of the shape of the incoming pipe water source, design of turbine and size, design of the blade, and the type of the generator.

ABSTRAK

Matlamat kajian ini adalah untuk mereka bentuk, membangunkan, analisis dan menghasilkan turbin Pico hidro mudah alih dengan kos yang rendah. Turbin hidro telah menjadi suatu kepentingan kerana ia digunakan secara meluas di seluruh dunia, terutama di kawasan luar bandar di Malaysia. Antara sebab utama mengapa turbin hidro yang digunakan begitu meluas adalah disebabkan oleh sumber yang boleh diperbaharui untuk menghasilkan tenaga elektrik iaitu air. Tumpuan kepada projek ini adalah untuk membangunkan turbin Pico hidro mudah alih yang boleh dipasang di mana-mana terutamanya di dalam rumah. Projek ini akan melibatkan dua fasa utama iaitu: mereka bentuk turbin dan analisis turbin menggunakan bentuk paip yang berbeza di sumber air yang masuk. Turbin direka harus mampu untuk memenuhi spesifikasi prestasi bagi penjanaan kuasa hidro seperti kadar minimum yang mencukupi aliran dan jenis reka bentuk turbin yang digunakan. Kuasa yang dibekalkan oleh air jatuh adalah kadar di mana pnghasilan tenaga ini bergantung kepada kadar aliran jisim air, yang boleh dimanipulasi oleh reka bentuk paip yang berbeza di sumber air masuk. Bagi memenuhi keperluan ini, beberapa isu perlu dipertimbangkan dalam mereka bentuk seperti pemilihan bentuk sumber air paip masuk, reka bentuk turbin dan saiz, reka bentuk mata turbin itu, dan jenis generator.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

V	-	Voltage
DC	-	Direct Current
AC	-	Alternating Current
m	-	Metre
g	-	Gravity = 9.81 m/s
W	-	Watt
M	-	Mega
K	-	Kilo
psi	-	Pound per square inch
RPM	-	Rotation per minute
Q	-	Flow rate
P	-	Pressure
H	-	Water head

CHAPTER 1

INTRODUCTION

Research on alternative ways to generate electricity is going aggressively because the dependence on non-renewable energy sources is diminishing. Hydro generation is one of the energy sources that have yet to be fully explored.

1.1 Project Background

This project is about the development of low cost and portable Pico hydro turbine. A hydro turbine is a renewable energy whereby it generates energy by converting kinetic energy from water movement into electricity. The Pico hydro turbine is another option for gathering electric power from moving water sources by using a small water turbine fed from a household water pipe. In this project, the usage of water turbine that suitable and can adapt to the small pressure of household water pipe will be focusing on.

Basically, this project will do an analysis of the best shape of the household incoming water pipe that can effect on the speed of the water turbine. In order to do an analysis, the selection of the water turbine shape and size will be greatly facilitated while keeping the

desired hardware aspect in mind. As for the desired hardware aspect, the selection of the blade design and the generator type to be used will be selected to comply with the requirement of the desired hardware. In this analysis, some finding or conclusion should be obtained to know the performance of the portable Pico hydro turbine in service.

1.2 Project Motivation

It is motivated to study and do this project because of the high demand from industry that need to produce a renewable energy in a minimum cost so that it can be installed widely especially at the rural area. Nowadays, the biggest problem of transferring electricity to the rural area is the cost itself. As the cost come with the problem, most of the electricity generation comes with a big size that will install permanently in the specific area. This unresolved problem has led to the lack of power generation in the rural area that can only be solved by designing a low cost and portable renewable energy turbine.

1.3 Problem Statement

The development of a low cost and portable Pico hydro turbine is not a simple task. Generally, knowledge of electrics, magnetics, electronics and mechanics is required. Thus, the electrical and mechanical relationships are important and should be taken into account in designing the portable Pico hydro turbine. Turbine selection and design are the most crucial parameter to be determined in designing the low cost and portable Pico hydro turbine, which is either to use the reaction turbine or impulse turbine. Selection of the generator will potentially affect the outcome of the project, either it can produce power at the determine rate.

For these reasons, it is important to design a good generator and turbine at smaller size with a reliable, affordable, economically viable and socially acceptable to ensure it will produce a smooth mechanical rotation and output.

1.4 Objectives

The objective of this project is to:

1. To understand the concept and the design of hydro turbine
2. To design and develop a low cost and portable Pico hydro turbine
3. To analyse the best shape to be used in the design of incoming water source pipe

1.5 Scope of Work

The scope of work is limited to:

1. The 12V DC motor will be used as the generator.
2. The shape of incoming water source pipe used is original shape, baffle shape and nozzle shape.
3. Minimizing the cost of the material that use of the turbine and the hardware.
4. Develop the hardware so that it can fit in the consumer's pipe.
5. Testing in the low-head hydro turbine (4m) parameter.

1.6 Contribution of Work

Hydropower is an extremely proficient wellspring of renewable energy. Due to the thickness of water and the power of gravity (among other factor) the hydropower innovative favourable circumstances of today are that these frameworks can clandestine up to 90% of the vitality of water into electric vitality, which is an astounding number [1][2].

Since hydro force is powered by water, it has the benefit of being just utilized when required, in light of the fact that it is anything but difficult to control the capacity and allowable flow of water into a hydropower framework. Hydropower has preference over wind power in light of the fact that water is thicker than air, so gathering the mechanical vitality of wind obliges a more prominent power of wind to turn the turbine than it would for water in a hydropower framework[2].

CHAPTER 2

LITERATURE REVIEW

Theories related in development of low cost and portable Pico hydro turbine will discuss in this chapter.

2.1 Theory and Basic Principles

Most of the energy in the world is wasted out without have been used in a proper way to gain an energy. The renewable source of energy such as water is the fundamental reason why hydropower is possible. The water cycle, which is starting from the sun that reaches the earth's surface causes water to operate and hence a proportion of this energy causes the vapour to rise against the earth's gravitational pull. This vapour then condenses into rain and snow, which again falls back to the earth's surface [3].

When rain and snow fall onto any ground above sea level, some of the sun's energy is conserved in the form of potential energy. This energy is then dissipated in currents as water runs down in streams. By catching this water in controlled form of pipe, we can exploit the

kinetic energy that becomes available with the movement of water, under pressure onto a turbine blade. The water then strikes the turbine blade to create mechanical energy [2] [3]. This mechanical energy is then transmitted to an electrical generator through a rotating shaft [2].

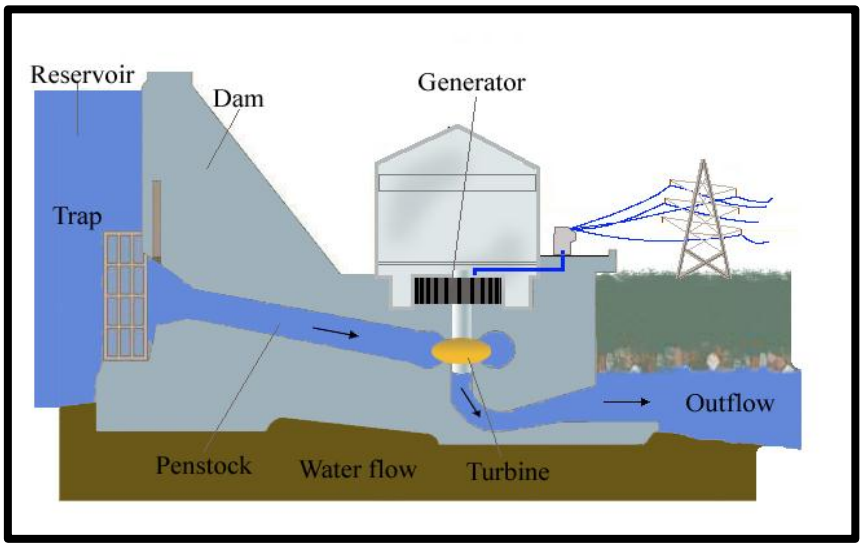

Figure 2.1: How hydro Turbine works [2]

The earliest reference to the use of the energy of falling water is found in the work of the Greek poet Antipater in the 4th century BC, however the Romans were the first to be documented as using waterwheels and they spread their use across Europe, in the form of mills for grinding cereals. By 1800, tens of thousands of such mills had been built worldwide [4].

By the end of the 19th century water wheel technology had advanced considerably and the first water turbines, as they were now called, were used to produce electricity. The earliest recorded hydroelectric plant began generating in 1882, in the USA, on the Fox River near Appleton, Wisconsin. Since that time the contribution of hydroelectric power to world use of electricity has risen steadily and today hydroelectricity is the principal source of electric power in some 30 countries and provides about 20% of the world's annual electrical output [4].

The very first hydro-plants were relatively small schemes, however, subsequent developments were around very large schemes and today most of the hydroelectric power is produced from very large hydro-plant associated with dams, which were major capital projects. Large dams are still being built today, however the majority are located in the developing world, where between 1980 and 1986 the absolute increase in hydro generation was almost twice that of the industrialized world [4].

The hydroelectric plants work by converting the kinetic energy from water falling into electric energy. This is achieved from water powering a turbine, and using the rotation movement to transfer energy through a shaft to an electric generator.

Figure 2.2: Early hydro turbine design [4]

Hydroelectric power, using the potential energy of rivers, now supplies 17.5% of the world's electricity (99% in Norway, 57% in Canada, 55% in Switzerland, 40% in Sweden, 7% in the USA) [4]. Apart from a few countries with an abundance of it, hydro capacity is normally applied to peak-load demand, because it is so readily stopped and started. It is not a major option for the future in the developed countries because most major sites in these countries having potential for harnessing gravity in this way are either being exploited already

or are unavailable for other reasons such as environmental considerations. Growth for 2030 is expected, mostly in China and Latin America.

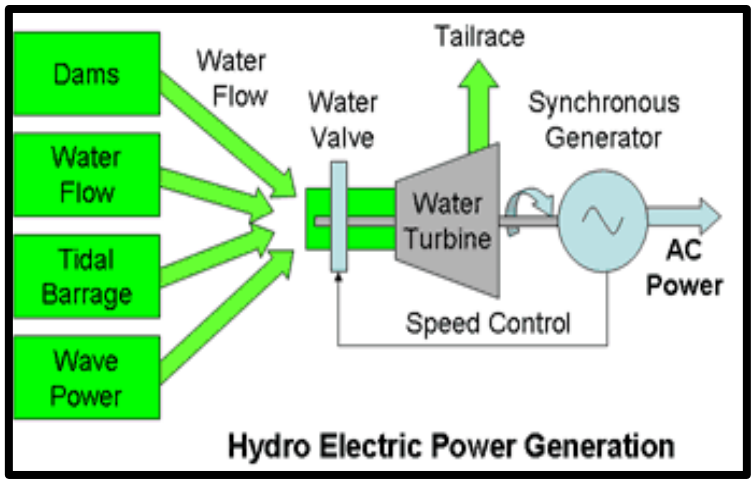

Figure 2.3: Sources for hydroelectric power [5]

Hydro energy is available in many forms, potential energy from high heads of water retained in dams, kinetic energy from current flow in rivers and tidal barrages, and kinetic energy also from the movement of waves on relatively static water masses. Many ingenious ways have been developed for harnessing this energy, but most involve directing the water flow through a turbine to generate electricity.

Hydro power is a very clean source of energy and only uses the water, the water after generating electrical power, is available for other purposes. Due to this reason, hydropower plants become more important. There are few types of hydropower plant which depends on the size which is the large, small, mini, micro, and Pico [5].

1. Large Hydro (10 MW or more of generating capacity)
2. Small Hydro (1 to 10 MW of generating capacity)
3. Mini Hydro (100 KW to 1 MW of generating capacity)
4. Micro Hydro (5 KW to 100 KW of generating capacity)
5. Pico Hydro (less than 5 KW of generating capacity)

2.2 Water Turbines

A water turbine is a rotary engine that takes energy from moving water. Water turbines were developed in the nineteenth century and were widely used for industrial power prior to electrical grids. Now they are mostly used for electric power generation. They harness a clean and renewable energy source.

Flowing water is directed onto the blades of a turbine runner, creating a force on the blades. Since the runner is spinning, the force acts through a distance (force acting through a distance is the definition of work). In this way, energy is transferred from the water flow to the turbine. Water turbines are divided into two groups; reaction turbines and impulse turbines. The precise shape of water turbine blades is a function of the supply pressure of water, and the type of impeller selected [6] [7].

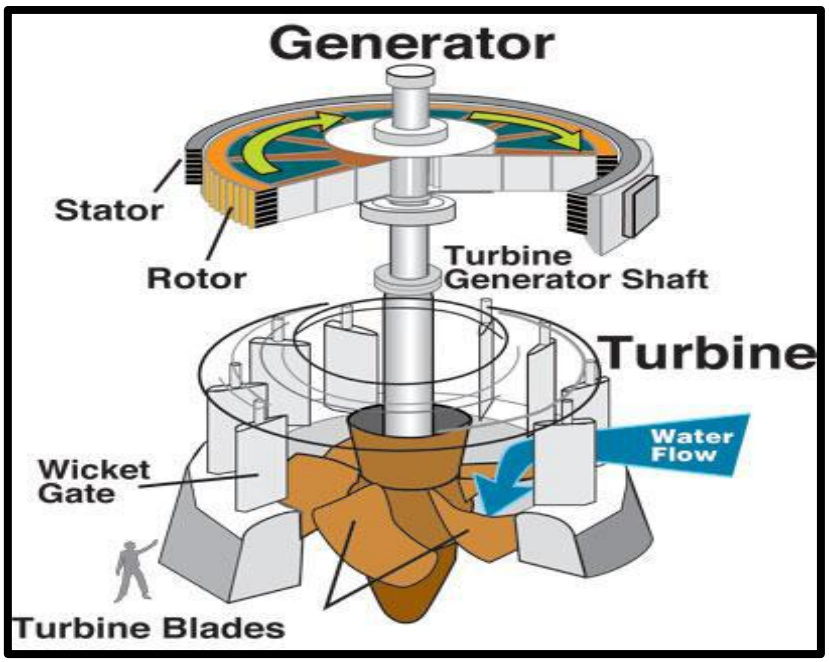

Figure 2.4: Hydraulic turbine and electrical generator, cutaway view [7]

2.2.1 Classification of Water Turbine

Water turbine fall into two categories which is:

1. Impulse Turbine
2. Reaction Turbine

2.2.2 Impulse Turbine

An impulse turbine operates on the same principle as a toy pinwheel. Water strikes the turbine runner, and pushes it in a circle. The water is delivered to the runner through a pipeline, and out a small nozzle which maximizes the force available to operate the turbine.

These types of water turbines work best on sites where the water source has high head (20 feet or more). The head is the vertical distance between where the water enters the turbine system (in this case, into a pipeline) and where it reaches the turbine runner. Small impulse water turbines require minimal water flow volume, so they are ideal for sites where a relatively small amount of water runs down a fairly steep hill, as in a hillside stream or small waterfall. The most well-known type of impulse turbine is the Pelton wheel style as used in Harris Pelton turbines. But in higher flow sites, a Turgo style runner such as the one used in the Stream Engine has a higher output potential [7].

Impulse turbines change the velocity of a water jet. The jet impinges on the turbine curved blades which change the direction of the flow. The resulting change in momentum (impulse) causes a force on the turbine blades. Since the turbine is spinning, the force acts through a distance (work) and the diverted water flow is left with diminished energy. Prior to hitting the turbine blades, the water pressure (potential energy) is converted to kinetic energy by a nozzle and focused on the turbine. No pressure change occurs at the turbine blades, and