DESIGN AND DEVELOPMENT OF MINI HYDROPOWER TRANSMISSION SYSTEM

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A thesis submitted
in fulfillment of the requirements for the degree of
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DECLARATION

I declare that this "DESIGN AND DEVELOPMENT OF MINI HYDROPOWER TRANSMISSION SYSTEM" entitled is the result of my own research except as cited in the references. The "DESIGN AND DEVELOPMENT OF MINI HYDROPOWER TRANSMISSION SYSTEM" has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : Keevanish

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Date : 11 JANUARY 2023

APPROVAL

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Mechanical and Manufacturing) with Honours.

Signature	:	
Supervisor Name	:	TS. AZRIN BIN AHMAD
Date	:	11 JANUARY 2023

DEDICATION

Dedicated to my beloved parents Mr. Suresh Chandra and Mrs. Sheela Pillai, who have respected and supported me in everything I do. Dedicated to Ts. Azrin Bin Ahmad, who taught and guided met throughout the journey of completing the final year project.

ABSTRACT

A hydropower plant is a device that generates energy by moving water. Small hydropower is a sustainable energy source that helps to minimise reliance on fossil fuels while reducing greenhouse gas emissions significantly. Remote locations, on the other hand, are far from any big city that has a significant waterpower plant. As a result, remote areas' access to energy is constantly limited. Furthermore, the functioning of the large hydroelectric plant necessitates the construction of a dam, which devastates the natural and environmental ecology of the area. As a result, a Pico hydropower system that is both environmentally friendly and capable of providing electricity to remote places is required. In addition, run-of-river hydropower plants account for most small hydropower plants. In design and development of this project, the house of quality was used to identify user and technical requirements, the morphological chart was used to develop several conceptual designs, the Pugh method was used to select the best gear for a pico hydropower system, and finally failure mode and effect analysis was used to identify potential failures of gears and ways to overcome the problem. In this research, the fabrication of micro hydropower plant was fabricated and the result shows that the micro hydropower plant is capable of producing 14.22 V of electricity at the water speed of 0.072 m^3/s. Furthermore, the fabrication of the gear was successful, and the simulation result also shows a promising result. It shows that the gear will only fail at the torque of 8500 N.m and proved that the gear is sturdy and robust thus it will not easily fail. As a conclusion, the result has successfully fulfilled the objectives stated in chapter 1. The fabricated hydropower plant can be very useful to be applied in the rural areas.

ABSTRAK

Loji kuasa hidro adalah satu mekanisme yang menghasilkan kuasa elektrik mengunakan aliran air. Loji kuasa hidro menghasilkan kuasa elektrik yang boleh diperbaharui yang membantu mengurangkan pengunaan bahan api fosil dan mengurangkan penyebaran gas rumah hijau. Selain daripada itu, kawasan pendalaman terletak jauh dari kawasan bandar yang mempunyai logi kuasa hidro yang besar. Ini menyebabkan kuasa elektrik yang diberikan kepada kawasan pendalaman terhad. Tambahan pula, loji kuasa hidro yang besar mempunyai empangan, yang menyebabkan kerosakkan alam sekitar. Justeru, sebuah penjana kuasa air yang kecil (pico) diperlukan untuk menyalurkan bekalan elektrik kepada kawasan pendalaman dan mesra ekologi. Kaedah-kaedah yang digunapakai adalah "house of quality", untuk mengenalpasti keperluan penguna dan keperluan teknikal, "morphological chart" untuk membangunkan beberapa konsep rekabentuk, kaedah "Pugh" untuk memilih gear yang paling sesuai untuk membina loji kuasa hidro kecil (pico) dan akhir sekali, "failure mode and effect analysis" untuk mengenalpasti potensi kegagalan sesebuah gear dan cara untuk mengatasinya. Dalam penyelidikan ini, fabrikasi loji kuasa mikro hidro telah dibuat dan keputusan menunjukkan loji kuasa hidro mikro mampu menghasilkan 14.22 V elektrik pada kelajuan air 0.072 m^3/s. Tambahan pula, fabrikasi gear telah berjaya dan hasil simulasi juga menunjukkan hasil yang memberangsangkan. Ia menunjukkan bahawa gear hanya akan gagal pada tork 8500 N.m dan membuktikan bahawa gear itu kukuh dan teguh dengan itu ia tidak akan mudah gagal. Kesimpulannya, hasilnya telah berjaya memenuhi objektif yang dinyatakan dalam bab 1. Loji janakuasa hidro yang difabrikasi boleh digunakan dan diaplikasikan di kawasan luar bandar.

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Last but not least, abundance of thanks to my dearest parents for their continuous support,love and understanding.

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LIST OF SYMBOLS AND ABBREVIATIONS

D,d	-	Diameter
PHP	-	Pico hydropower plant
kW	-	Kilo watts
PHPP	-	Pico Hydro Power Plant
PHPG	-	Pico Hydro Power Generator
GMA	-	General Morphological Analysis
QFD	-	Quality Function Deployment
VOCs	-	Voice of Customers
PVC	-	Polyvinyl Chloride

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CHAPTER 1

INTRODUCTION

1.1 Background Study

The development of the global economy relies heavily on the availability of energy. Many industrial, residential, and agricultural operations have risen rapidly in order to meet the wants of consumers. As a result, worldwide primary energy consumption is anticipated to climb by 1.6 percent year between 2009 and 2030. Traditional biomass for cooking remains popular in many countries and 1.6billion people still do not have access to electricity. According to UN-Energy, the world's environmental sustainability suffers tremendously as a result of this energy deficit (Yah et al., 2017). To close the energy gap, it is vital to have more equitable and convenient access to energy services.

A renewable energy resource is the most environmentally friendly form of energy that does not contribute to climate change. In addition to reducing secondary waste, this source of energy can also be sustainable for current and future societal needs. Renewable energy made up 14 percent and 19 percent of worldwide power generation in 2010 and 2012, respectively. According to Malaysia's renewable energy commission, a 5.5 percent increase in electricity generated from renewable sources was planned for 2012 by a government body.

Hydropower is the world's most frequently used renewable energy source, accounting for 19 percent of the world's total electricity generation. According to the Department of Energy (DOE), large hydropower is defined as power stations with more than 30 MW of generation capacity. Small hydropower facilities have a generation capacity of 100 KW to 30 MW. For the purposes of this definition, micro hydropower plants are those with an output of 5 to 100 kW (Razan et al., 2012). With the right application of advanced technology, water heads as high as 2 meters can be used to generate power efficiently. The grid network's uneconomical planning is to blame for the energy challenges in rural and hilly places. A low-cost alternative for these outlying locations is micro-hydropower. For rural and hilly places where extending the grid system would be prohibitively expensive, it is an excellent answer to energy problems.

Hydroelectric hydropower with a maximum output of five kilowatts is known as Pico hydroelectric power. Using Pico hydroelectricity, which can power just one or two fluorescent light bulbs and a TV or radio in each of 50 houses, is ideal for remote, rural communities. Current research and development efforts to develop this green Pico hydro power technology are quite exciting. There are various advantages in terms of capacity, cost-effectiveness, size, design, and installation when these efforts are compared to other larger hydroelectric sources of power. In addition to being inexpensive, Pico hydro can enhance the lives of people in developing countries and rural areas where the government has difficulty constructing transmission lines. To generate electricity at Pico, we used proven hydropower technologies. The generator will be powered by the spinning of the turbine, which will generate electricity. This is the most crucial aspect of hydropower concepts.

It is presented in this thesis how a Pico hydropower project's transmission infrastructure was designed and developed. The turbine, penstock, shaft, and the entire hydropower plant were all taken into account throughout the analysis. To test this hydroelectric system, the water of a nearby river was used as a source of water. The hydroelectric plant consists of a water intake, penstock, hydro turbine, gear system with shaft, and generator.

1.2 Problem Statement

Hydroelectric plants do not produce the waste heat and gases that are produced by plants that are fueled by fossil fuels. These emissions are a key contributor to issues such as air pollution, global warming, and acid rain. The challenge is that, despite the fact that hydropower plants are a renewable source of energy that is great for the environment, the construction of a dam for a hydropower plant may cause damage to or have a negative impact on the environment both upstream and downstream while the dam is being built. A pico hydropower (PHP) system is a more environment friendly renewable energy. This is because the hydraulic works can be made simple and large constructions such as dams are usually not required. This PHP is simple to be installed due to the parts like pipes, generators and others are usually cheap and easy to find.

In addition, the construction of dams slows the flow of water, which reduces the amount of oxygen that is present in the water. There is a possibility that decreasing oxygen levels behind the dam will lead to decreased oxygen levels further downstream. When there is less oxygen in the water, it is more difficult for some fish species to survive, which can have a negative effect on the ecosystem of a river. Dams pose a significant risk to the migratory of fish, particularly for species like salmon that are reliant on rivers for their reproductive processes.

This pico hydropower system has become more and more important due to few reasons. The first is the system is this system is close to the demander place, hence the development cost is way much cheaper and the money is saved up. Besides, micro hydropower system has become more demandable due to the increasing of energy price worldwide.

1.3 Research Objective

The main aim of this research is to design of a better micro hydropower gear system, which should be evaluated in real-world conditions. Specifically, the objectives are as follows:

i. To identify the technical requirements of a pico hydropower transmission system.

ii. To study and design the improvement of pico hydropower transmission system which should be tested at real condition.

iii. To analyze the efficiency and power output of the pico hydropower transmission system.

1.4 Scope of Research

Defining the project's scope means determining exactly what it is that must be studied in order for it to proceed smoothly. The scope of this research are as follows:

i. An appropriate transmission system for use with the modified water turbine must be selected and built.

ii. Pico hydropower system, which may produce 200W to 5kW of power.

iii. Installing a hydropower plant.

iv. Showing that this customised water turbine is capable of generating power in a real-world environment (full scale).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The availability of electric electricity is essential to the functioning of daily life because it is a necessity. The disparity between the demand for and supply of energy continues to expand, and as a result, its provision is becoming increasingly unfeasible. As a result, the majority of rural areas do not have connection to the power grid. As a direct consequence of this, there is a substantial demand for the generation of power in rural areas. The Pico Hydro Power Plant (PHPP) is one of the developing alternatives for rural electrification. This is due to the fact that it was created in close proximity to valleys and small rivers that are located far away from the national grid. The amount of electricity that can be generated using PHPP ranges from 0 kW to 5 kW. The powerhouse of the PHPP is located directly on the runway stream, and there are only minimal facilities for directing water towards the powerhouse; as a result, there is no requirement for a hydro governor. As a consequence of this, PHPP does not require the use of a reservoir in order to produce energy. The water that comes from the runway stream is diverted to the tailrace so that it can be used to create energy. The water is then redirected back to the runway stream. In contrast to large hydroelectric power plants, the Philippine Hydroelectric Power Plant (PHPP) has a marginal impact on the environment. The PHPP Powerhouse is situated in a place far from the national grid, which should result in a reduced need for maintenance. In addition, the powerhouse needs to be equipped with a reliable control system in order to maintain constant power generation. A reliable control system will have a consistent transmission, which will ultimately lead to consistent speeds for both the turbine and the generator. Because of the uneven flow of water, a hydroelectric system without a hydro governor will have variable turbine speed, which will result in variable generator speed. The installation of PHPP is a challenging endeavour to undertake because there is currently no technological breakthrough that can keep the speed of the generator constant. As a consequence of this, an innovative design for the transmission system is required in order to keep the speed of the generator constant despite variations in the speed of the input turbine.

2.2 Distribution Network Configurations and Components

2.2.1 Direct Transmission

In direct transmission, the turbine and generator shafts are connected in a direct connection, resulting in extremely high efficiency. This means that both turbine and generator must be custom-built, which is a waste of time and money. As a result, it is not suited for PHPP use.

2.2.2 Indirect Tranmission

An indirect transmission system is used to ensure that the turbine and generator are operating at the same speed. To compensate for the fact that normal generators operate at a substantially greater rate of rotation per minute, a speed multiplier is used in PHPP. Many indirect transmission technologies are available for PHPP according to literature. Because of its limited efficiency and load sharing capacity, chain and belt drive is only employed in applications requiring a low transmission ratio and generating power of less than 3 kW.

2.2.3 Types of Gear

Belts, chains, and gears are a few of the possibilities for connecting the generator to the turbine in hydro systems. Their cost is so low that they aren't a substantial part of the overall plant cost when utilised with standardised turbines for modest hydropower projects that require gearing. The advantages and downsides of each type can be found:

i. **Spur Gears**, due to their relatively limited transmission ratio, which is required by their total dimensions, these devices are often utilised for low-power applications only. Figure 2.1 shows the spur gear.

Figure 2.1 The spur gear.

ii. **Orthogonal Bevel Gears**, this type of transmission system is only suitable for low-power applications because it can only be utilised with a modest transmission ratio. Figure 2.2 shows the orthogonal bevel gear.

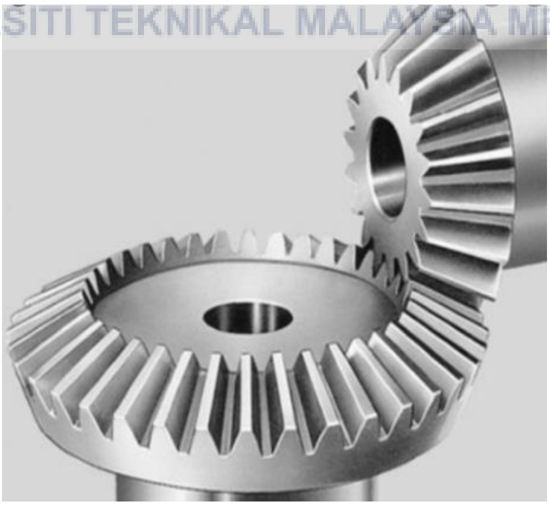

Figure 2.2 The orthogonal bevel gear.

iii. **Belt Transmission**, trapezoidal belt transmissions are the most common in hydropower plants, although their efficiency is low, making them ideal for low-