Faculty of Mechanical and Manufacturing Engineering Technology

DESIGN AND ANALYSIS MINI HYDRO POWER TURBINE BLADE

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Bachelor of Mechanical Engineering Technology (Maintenance) with Honours.

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A report submitted in fulfilment of the requirement for the Bachelor of Mechanical Engineering Technology (Maintenance) with Honours.

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This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Maintenance) with Honours. The member of the supervisory is as follow:

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Supervisor's Name : Ts. Azrin bin Ahmad

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DEDICATION

To my beloved parents who taught me that the best kind of knowledge to have is learned for its own sake. It is also dedicated to my supervisor who taught me that even the largest task can be accomplished if it is done one step at a time.

ABSTRAK

Kajian ini membincangkan tentang reka bentuk dan analisis bilah turbin mini untuk penjanaan kuasa hidroelektrik. Turbin mini untuk penjanaan kuasa hidroelektrik. telah diperlukan disebabkan oleh pembinaan empangan memerlukan kos yang terlalu tinggi dan telah berkesan kepada ekosistem. Oleh kerana aliran sungai lebih rendah berbanding dengan aliran air di empangan, turbin mini untuk penjanaan kuasa hydroelektrik diperlukan untuk menghasilkan tenaga elektrik dalam halaju air rendah dan tekanan rendah. Oleh itu, bilah turbin lingkaran dipilih untuk dianalisis dan direka oleh pencetak 3D dalam projek ini. Bilah turbin lingkaran ini boleh dikendalikan dengan halaju air rendah dan tekanan yang rendah untuk mencegah haiwan laut daripada kebinasaan. Kawasan permukaan bilah turbin lingkaran dan bilah itu sesuai untuk halaju rendah kerana radius kecilnya dapat menjana daya tarikan kecil. Turbin lingkaran akan direka dan dilukis dengan menggunakan SOLIDWORKS. Selain itu, bilah turbin lingkaran direka dengan menggunakan pencetak 3D. Jadi, masa pemprosesan telah dapat dikurangkan dan akan dapat menjimatkan kos. Bahan yang digunakan untuk menghasilkan bilah lingkaran adalah Poliamida 12. Poliamida 12 adalah yang dapat menahan tekanan tinggi dan halaju air tinggi. Selain itu, simulasi aliran dan simulasi tekanan akan dianalisis menggunakan Computational Fluid Dynamics (CFD). Jumlah voltan yang dihasilkan, dan kelajuan putaran bilah lingkaran akan direkodkan dalam kedua-dua eksperimen yang menggunakan bilah turbin lingkaran dengan ruang tutup dan lingkaran turbin spiral tanpa ruang tutup. Hasil kecekapan bilah lingkaran akan dikira dan dibandingkan antara bilah lingkaran dengan ruang tutup dan tanpa ruang tutup. Keputusan menunjukkan bahawa bilah turbin lingkaran dengan memasang ruang tutup dapat menghasilkan halaju, laju putaran dan voltan yang lebih tinggi daripada tanpa memasang ruang tutup.

ABSTRACT

This study discusses about the design and analysis mini hydro power turbine blade. The mini hydro power turbine has become more useful since the dam construction is too high cost and ecosystem impact. As the flow rate of the rivers or stream is lower comparing to the dam construction, the mini hydro power turbine is needed to be to generate electricity in the low water velocity and low head. Hence, the spiral turbine blade is decided to be analyzed and fabricated by 3D printer in this experiment. This kind of turbine blade can be operated in low water velocity and low head thus it can avoid harming the marine life. The spiral turbine blade's surface area and its own blades are suitable for low velocity as its small radius can generate a little traction force. The spiral turbine blade is designed by Quality Functional Deployment (QFD), Morphological chart and Failure modes, effects, and critical analysis. It is then drawn by using SOLIDWORKS software. Furthermore, the spiral turbine blade is fabricated by using 3D printer, so the processing time has been reduced and cost saving. The material that used by produce spiral blade is Polyamide 12 as this kind of material can withstand high pressure and high-water velocity. Moreover, the flow simulation and pressure simulation are analyzed by Computational Fluid Dynamics (CFD). The results of voltage produced, and rotational speed of spiral blade will be recorded in both experiments which are spiral turbine blade with and without the chamber. The results of efficiency of spiral blade is calculated and will be compared in between spiral blade with and add without the chamber. The results showed that the spiral turbine blade with installing collecting chamber can produce higher velocity, rotational speed, and voltage than without installing collecting chamber.

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LIST OF SYMBOLS

P_t	-	Power of turbine shaft (watt)
P_l	-	Load power (watt)
g	-	Gravity = 9.81 m/s
H_n	-	Net head (m)
Q	-	Water flow rate (m^3/s)
η_t	-	Turbine efficiency
N	-	Rotational velocity
P	-	Pressure
p	-	Density of water ($1000kg/m^3$)
B	-	Turbine and generator friction torque coefficient (N.m/(rad./sec.))
T	-	Torque
J	-	Moment of inertia of the whole rotating system (kg/m^2)

LIST OF ABBREVIATIONS

CATIA	Computer aided three-dimensional interactive application
ANSYS	Analysis system
QFD	Quality functional deployment
FMECA	Failures modes, effects and critical analysis
VOC	Customer's voice
CFD	Computational Fluid Dynamics
SLS	Selective Laser Sintering

CHAPTER 1

INTRODUCTION

1.1 Background

Renewable energy is defined as the natural energy which consist of solar, hydro and wind where these energies can be reproduced and reused repeatedly. All the natural resources above are clean resources which would not pollute the environment. Besides, renewable energy can be classified into two types which are large renewable energy generation and small renewable energy generation (Ellabban, Abu-Rub, & Blaabjerg, 2014). Large renewable energy generation usually in touch with the large project such as hydropower and wind farms while the small power productive equipment like mini hydro power turbine will be classified as small renewable energy generation (Athula Rajapakse, 2009). Mini hydro power turbine which is the small renewable energy can produce the power between 5kW to 100kW. It is considered as ordinary and stable among all types of renewable energy. These installations gain a lot of benefit like environmental conservation and cost saving especially for those homeowners and small business owners. One of the foremost style concerns in mini hydro power turbine is to reduce the water flow which unable to cross to achieve maximum efficiency (Khan & Badshah, 2014). The potential of the mini hydro power turbine depends on many types of parameters. The factors include the design of the blades which will transfer the kinetic energy to electrical energy, runners, and turbine power. The example of the design of mini hydro power turbine blade is shown in Figure 1.0. (Source: U.S. Army Corps of Engineers)

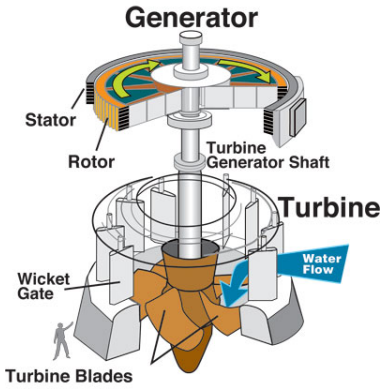

Figure 1.1: Example of mini hydro turbine

(Source: U.S. Army Corps of Engineers)

The design of turbines and blades with numerous patterns decide the power of the mini hydro turbine to produce energy from different rate of water flow and to come up with more electrical energy. A spiral turbine blade is a new design which enable transferring kinetic energy from water flow more efficiency (Monatrakul & Suntivarakorn, 2017). This kind of design maintains the balance of ecosystem as it will reduce harming marine animals due to its low velocity rotating system. Furthermore, the spiral turbine can generate limited adherence force as its small radius blade design. This kind of turbine blade has better efficiency when it is in low velocity flow rate of water and additional appropriate than the other kind of turbine blade after analyzing with the small sized water receiving area.

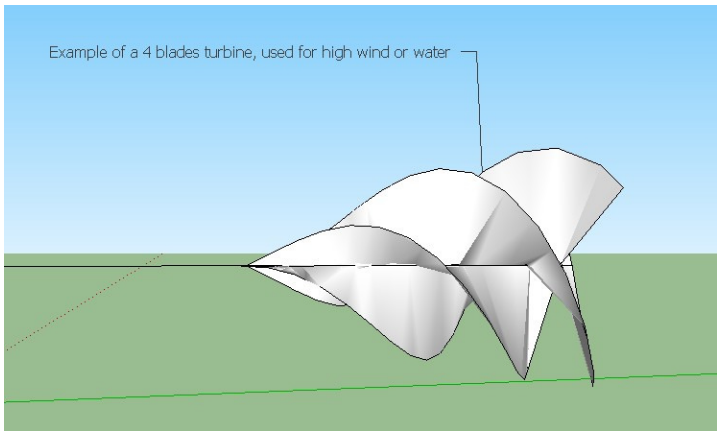

Figure 1.2: Mini hydro power turbine blade

(Source: Goldenspiralturbine, 2015)

The objective of this project is to design and fabricate the mini hydro power turbine blade which could maximize the efficiency of the mini hydro turbine. The result of this study is to fabricate and analysis a functioning micro hydro turbine. Figure 1.2 shows the example of mini hydro power turbine blade.

1.2 Statement of the Purpose

1. To design a mini hydro power turbine blade that can maximize its efficiency by using the SOLIDWORKS.
2. To fabricate the mini hydro turbine blade using 3D printer.
3. To analyse the efficiency of the spiral type of mini hydro power turbine blade.

1.3 Problem Statement

The development of hydro power plants through dam construction nowadays is hard because of the high investment costs, opposite from people and unfriendly to the ecosystem. The high velocity of the hydro turbine and the design of mini hydro turbine blade will affect the ecosystem of the marine life. Furthermore, the high cost of development of hydro power plants will cause the association to oppose encounter. Thus, the design of spiral turbine blade is intended to save cost and can be used in mini hydro turbine which has optimal performance and able to be operated in low velocity of water such as in the narrow space like mountain river or stream in rural area. Besides, this type of design maintains the balance of ecosystem as it will reduce harming the marine animals due to its low velocity rotating system.

1.4 Scope of work

1. The design process of the mini hydro turbine blade will be using the SOLIDWORKS software.
2. The mini hydro turbine blade will be fabricated by using 3D printer.
3. The analysis will be carried out by SOLIDWORKS included flow simulation and pressure simulation.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides the literature review based on the previous researches as well as the design and analysis based on the mini hydro power turbine blade. The literature review done based on the previous researches will help improving the methodology of this project and the result will be recorded successfully.

2.2 Hydropower

Hydro-power are often thought of because it is the most adorable supply of electricity due to its environmentally receptive energy source and good conversion efficiencies among all identified energy resources. (Ighodalo Okhueleigbe, 2019). The concept of the operation of the hydro power plant is acquiring the power from the flow of the water from higher level to the lower level which using the theory of head and flow. The head and flow from the water falls and velocity can be accommodated and controlled to generate hydro power that will be transferred into electrical energy to be used in daily life.

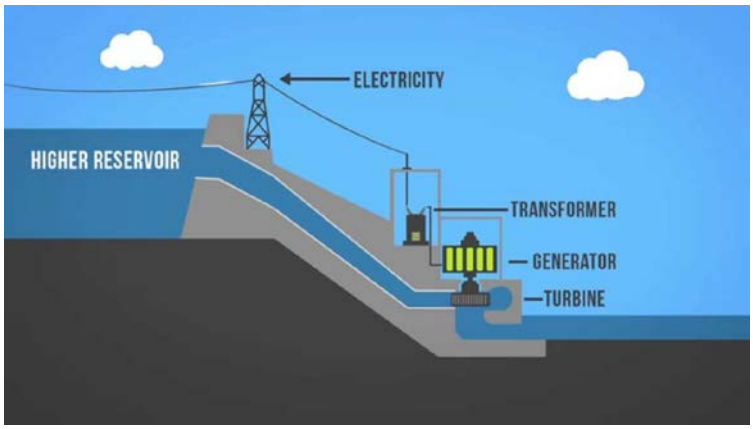

Figure 2.1: Hydropower

(Source: https://i.ytimg.com/vi/q8HmRLCgDAI/maxresdefault.jpg)

However, the development of hydro-power plant these few years through dam construction which is classified as large renewable energy generation become more difficult due to high risk of investment, unfriendly to the ecosystem, association encounter and other factors (Monatrakul & Suntivarakorn, 2017). For solving these problems, several mini hydro power schemes have been created which has long lifespan and low operation and maintenance cost. There are several types of turbines such as Pelton turbine, Turgo turbine and crossflow turbines. The crossflow turbine has become more popular due to it can be assembled and fabricated easily and efficiently in the manufacturing power plant site

2.3 Head and flow

Head, known as the water falling vertically, is the basic for all the hydro power plant generation. It can be defined by the change of water absorption and water releasing point. Although the water is flowing quickly on itself, it doesn't contain enough energy to produce hydro power as it required two quantities which are the head, H and water flow rate, Q. Besides, the relationship between head and water pressure is directly proportional.