Faculty of Engineering

TIDAL POWER PLANT SCHEME AT KUCHING BARRAGE, SARAWAK

Easter Izzaline Anak Meli

Bachelor of Engineering with Honours

(Mechanical and Manufacturing Engineering)

2017

UNIVERSITI MALAYSIA SARAWAK

Grade: ____________

Please tick (√)

Final Year Project Report	✓
Masters	
PhD	

DECLARATION OF ORIGINAL WORK

This declaration is made on the ......28........day of.....JUNE......2017.

Student's Declaration:

I EASTER IZZALINE ANAK MELI with the matric number 41064 from FACULTY OF ENGINEERING hereby declare that the work entitled TIDAL POWER PLANT SCHEME AT KUCHING BARRAGE, SARAWAK is my original work. I have not copied from any other students' work or from any other sources except where due reference or acknowledgement is made explicitly in the text, nor has any part been written for me by another person.

28/06/2017
Date submitted

EASTER IZZALINE ANAK MELI (41064)

Supervisor's Declaration:

I PROF. IR. DR. ANDREW RAGAI HENRY RIGIT hereby certifies that the work entitled TIDAL POWER PLANT SCHEME AT KUCHING BARRAGE, SARAWAK was prepared by the above named student, and was submitted to the "FACULTY" as a * partial/full fulfillment for the conferment of BACHELOR'S DEGREE OF MECHANICAL AND MANUFACTURING and the aforementioned work, to the best of my knowledge, is the said student's work.

Received for examination by: ______________________ Date: 28/6/2017

(PROF. IR. DR. ANDREW RAGAI HENRY RIGIT)

I declare that Project/Thesis is classified as (Please tick (√)):

☐ **CONFIDENTIAL** (Contains confidential information under the Official Secret Act 1972)*
☐ **RESTRICTED** (Contains restricted information as specified by the organisation where research was done)*
☑ **OPEN ACCESS**

Validation of Project/Thesis

I therefore duly affirm with free consent and willingly declare that this said Project/Thesis shall be placed officially in the Centre for Academic Information Services with the abiding interest and rights as follows:

- This Project/Thesis is the sole legal property of Universiti Malaysia Sarawak (UNIMAS).
- The Centre for Academic Information Services has the lawful right to make copies for the purpose of academic and research only and not for other purpose.
- The Centre for Academic Information Services has the lawful right to digitalise the content for the Local Content Database.
- The Centre for Academic Information Services has the lawful right to make copies of the Project/Thesis for academic exchange between Higher Learning Institute.
- No dispute or any claim shall arise from the student itself neither third party on this Project/Thesis once it becomes the sole property of UNIMAS.
- This Project/Thesis or any material, data and information related to it shall not be distributed, published or disclosed to any party by the student except with UNIMAS permission.

Student signature: ________ (Date: 28/06/2017)

Supervisor signature: ________ (Date: 28/6/2017)

Current Address:
NO. 2, KAMPUNG SEBIRIS, 94500 LUNDU SARAWAK

Notes: * If the Project/Thesis is **CONFIDENTIAL** or **RESTRICTED**, please attach together as annexure a letter from the organisation with the period and reasons of confidentiality and restriction.

[The instrument is duly prepared by The Centre for Academic Information Services]

TIDAL POWER PLANT SCHEME AT KUCHING BARRAGE, SARAWAK

EASTER IZZALINE ANAK MELI

A dissertation submitted in partial fulfilment
of the requirement for the degree of
Bachelor of Engineering with Honours
(Mechanical and Manufacturing Engineering)

Faculty of Engineering
Universiti Malaysia Sarawak

2017

A dedication to myself

ACKNOWLEDGEMENTS

My deepest gratitude to my supervisor, Professor Ir. Dr. Andrew Ragai Henry Rigit of University Malaysia Sarawak from Mechanical and Manufacturing Engineering department for his guidance and motivation throughout the one year period of completing this thesis. I would also like to express my gratitude to Mr. Kamran Ahmed Samo for his kindness and willing to share his knowledge regarding this thesis. This thesis could not have been completed without the guidance of these two respected people. A lot of thanks and love to my family for encouraging me in my study and patiently waiting five years for me to complete my pre-university and undergraduate study in University Malaysia Sarawak. Lastly, I would like to sincerely acknowledge my friends that I have met during this five years journey for their help and companion. No words could be used to express my gratitude towards them. I sincerely wish the best for everyone from this point onwards.

ABSTRACT

Renewable energy is the best solution and alternative to overcome the world growing energy demand and fossil fuels deficiency. Tidal energy is also a type of renewable energy that uses barrage and tide height difference to extract energy. Kuching Barrage located in Sarawak was built to mitigate flood in the city of Kuching and has the potential for development into tidal power station. The purpose of this project is to propose suitable tidal power plant scheme for tidal energy harnessing at Kuching Barrage. The site parameters, tidal range and flow rate were investigated in this study. Pending tide tables were used to estimate tidal range of the site and statistical analysis discovered the tidal range was 6.8 m. Theoretical calculation of the barrage gates discharged was 1443.82 m^3/s. Based on these parameters of Kuching Barrage, bulb-type turbine with rated power of 8.65 MW was chosen as the suitable turbine to be deployed. Power estimation of the site also discovered that Kuching Barrage average daily potential energy was 20.17 MW and approximately 35.41 GWh/year could be harness. The study showed that Kuching Barrage has the potential for installation of tidal barrage power plant for tidal energy harnessing. If Kuching Barrage were to be used for tidal energy harnessing the tidal power plant would operate by ebb generation or during the barrage daily flushing operation. The tidal power plant scheme at Kuching Barrage would be a single basin and one-way operation. Additional powerhouse structure should be constructed if the tidal scheme were to be implemented and CAD drawing of the powerhouse was produced using AutoCad in this project. It was estimated that the powerhouse structure would be 56.21 m in length; 125 m in width and with the height of 35.51 m.

ABSTRAK

Tenaga yang boleh diperbaharui merupakan langkah penyelesaian terbaik dan alternatif bagi mengatasi permintaan tenaga dunia dan kekurangan bahan api fosil. Tenaga pasang surut juga adalah tenaga yang boleh diperbaharui yang menggunakan baraj dan perbezaan ketinggian air pasang surut untuk penjanaan kuasa. Baraj Kuching bertempat di Sarawak telah dibina sebagai langkah untuk mengurangkan banjir di bandar raya Kuching, mempunyai potensi untuk dibangunankan sebagai stesen janakuasa daripada pasang surut. Tujuan projek ini adalah untuk mencadangkan skim loji janakuasa pasang surut yang sesuai untuk pemanfaatan tenaga pasang surut di Baraj Kuching. Parameter lokasi iaitu perbezaan ketinggian air pasang surut dan kadar aliran air telah disiasat dalam kajian ini. Jadual air pasang surut bagi Pending telah digunakan dalam kajian ini dan analisis statistik menemui julat pasang surut adalah pada paras ketinggian 6.8 m. Pengiraan secara teori kadar aliran air melalui pintu baraj adalah 1443,82 $m^{3/}s$. Berdasarkan parameter yang dikaji, turbin '*bulb-type'* dengan kadar kuasa 8.65 MW telah dipilih sebagai turbin yang sesuai untuk digunakan di Baraj Kuching. Anggaran kuasa berdasarkan Baraj Kuching memperolehi purata tenaga keupayaan harian sebanyak 20.17 MW dan kira-kira 35.41 GWh/tahun boleh dijana. Kajian ini menunjukkan bahawa Baraj Kuching mempunyai potensi untuk dibangunkan sebagai stesen janakuasa elektrik daripada pemanfaatan tenaga keupayaan perbezaan ketinggian air pasang surut. Sekiranya Baraj Kuching digunakan untuk menjanakuasa pasang surut, operasi penjanaan kuasa elektrik akan dilakukan ketika air laut surut serentak dengan operasi pembersihan harian. Skim stesen janakuasa pasang surut di Baraj Kuching akan mempunyai basin tunggal dan turbin hanya akan beroperasi satu hala sahaja. Struktur tambahan bagi rumah janakuasa perlu dibina jika skim ini akan dilaksanakan dan lukisan CAD telah dihasilkan menggunakan AutoCad dalam projek ini bagi memberikan gambaran tentang stesen janakuasa yang telah dicadangkan. Struktur rumah janakuasa tersebut dianggarkan mempunyai kepanjangan sebanyak 56.21 m; 125 m lebar dengan ketinggian 35,51 m.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

A	-	Flow area through the hydraulic structure
A_b	-	Horizontal area of basin
C_d	-	Discharge coefficient for sluice gate
d	-	Distance of the water molecule from the Moon or Sun
E_p	-	Potential energy over a tide cycle
E_{yr}	-	Potential annual tidal power output
F_{grav}	-	Gravitation force
G	-	Universal gravitation constant
g	-	Acceleration due to the Earth's gravity
H	-	Water head or tidal range
Δh_b	-	Mean tidal range in basin
m_1	-	The mass of the molecule of water
m_2	-	The mass of the molecule of water
P	-	Estimated power output
ρ	-	Density of sea water
Q_s	-	Discharge through sluice gate
Q_t	-	Discharge through turbine
Z_u	-	Upstream water level
Z_d	-	Downstream water level
η_p	-	Efficiency of power conversion
η_t	-	Efficiency coefficient of turbine

LIST OF ABBREVIATIONS

CAD	-	Computer-aided Design
CIA	-	Central Intelligence Agency
CRISIL	-	Risk and Infrastructure Solutions Limited
LSD	-	Low Surface Datum
MSL	-	Mean Sea Level
SEDA	-	Sustainable Energy Development Authority
SSRS	-	Sungai Sarawak Regulation Scheme

CHAPTER 1

INTRODUCTION

1.1 Background of Project

This project focuses on harnessing energy from low and high tides. The country's total coastline is 4, 675 km with West Malaysia and East having 2, 068 km and 2, 607 km of coastline respectively (CIA, 2016). The vast area of Malaysia's coastline is a huge advantage making tidal energy a reliable alternative energy source for the country (Shafie, Mahlia, Masjuki, & Andriyana, 2011). Although tidal energy in Malaysia is still in the preliminary studies, the potential of tidal energy harnessing should not be overlook. Lake Sihwa tidal power plant, South Korea and La Rance, France has the installed capacity of 254 MW and 240 MW respectively (Xia, Flaconer, Lin, & Tan, 2012). The large power harnessing from tidal power plant shows promising energy extraction from tides.

This project covers the study of tidal range technologies and its installation method at Kuching Barrage in Sarawak. Energy extraction from low and high tide is done using tidal range technologies. The commercial feasibility of tidal range technologies is substantiated by the large operations tidal power plant in France, Canada, Russia, South Korea and China (International Renewable Energy Agency, 2014). Waters and Aggidis (2016) stated that the amount of energy harnessed from tidal range technologies is tremendous, compared to any other single renewable energy.

1.2 Motivation of Project

Renewable energy in Malaysia continues to be developed and improved as the country moves toward green energy generation. Malaysia has several operating renewable energy power plants all over the country and continuous proposals on renewable energy power plant shows the positive support on renewable energy resources. The significant renewable energy sources in Malaysia are from solar photovoltaic (PV), biogas, biomass and small hydro. In the coming four years the government targets the electric generation from renewable energy is to be 2080 MW. However Sustainable Energy Development Authority (SEDA) Malaysia (2016) reported that by 2020 the target would be impossible to achieve as by 30th September 2015 energy production from renewable energy only recorded approximately 319.55 MW of total power production. The total energy production is only 32% of that yearly target. Malaysia should reinforce the country's efforts to make use of renewable energy for electric production. This project is done as a way to raise awareness on renewable energy in Malaysia especially in tidal range technologies as Malaysia has no existing tidal power plant.

Apart from supporting the government's initiatives to make use renewable energy for electric production and promoting tidal energy, this project is also done to propose a new energy extraction method in Malaysia which is from tides. Malaysia is among the world's largest solar module manufacture but most of these solar modules are exported (Leong, 2011). In the year 2015, SEDA reported the commercial application capacity of solar PV is only 209.11 MW. Similarly biogas, biomass and small hydro contribute an approximate total 110.49 MW electrical energy. High start-up costing, reliability and environmental issues are among the factors contributing to low electric power generation from renewable energy. Solar and wind energy power production for example is greatly affected by climate change. Unlike any other renewable energy, low and high tide energy harvesting is predictable. Specific amount of energy outputs from tidal power plant can be estimated accurately (Waters & Aggidis, 2016). This factors itself would be a great investment.

1.3 Problem Statement

About 40 sites have been identified worldwide as the most suitable site for tidal range technology harvesting (Thorpe, n. d., as cited in Etemadi, Emami, AsefAfshar, & Emdadi, 2012). The number recorded is relatively low and Malaysia is not among the sites suggested. Further studies in Malaysia's ocean and technologies improvement is expected can overcome the limitation of tidal energy in Malaysia.

There are various methods to harness energy from the ocean such as using barrage, artificial lagoon or in-stream turbine. However, some site may not be suitable for certain method of harnessing taking into account how much the estimated total power can be generated with the different methods of harnessing (Xia, Falconer & Lin, 2009). Since this project is a study on low and high tides energy harvesting technology, thus the scope of project is limited to tidal power plant. Thus, how a tidal power plant is going to be implemented at a propose site is going to be investigate and analyse. Structural design of the barrage should be considered as well as the size of the basin because these factors affect the barrage operation.

What type of turbine would be suitable for the proposed tidal power plant scheme should also be considered based on the parameters of site. Xia, Falconer and Lin (2010) stated that minimum water head for turbines operation ranges between 1 to 1.5 m. Most tidal power plant uses low head turbine for power extraction. There are two important parameters that should be considered to implement a tidal barrage. These parameters are the water head of the barrage and water flow rate of the site. In tidal barrage, water head is the difference between the height of water at the upstream of barrage and the downstream of barrage. The starting head and minimum head of site will affect power output. Flow rate will affect the operation of the turbine.

Lastly, a specific site can only harness energy at a certain capacity and so to know how much expected power generation of a proposed site is also important to determine the feasibility of the proposed tidal power plant project. After a specific site is identified for a tidal power plant, the parameters of the site should be analysed accordingly. These parameters include tidal range, flow, pattern, geography of coastline and type of tidal energy harvesting technology to be implemented. Benefiting from the collected site parameters, how much expected power generation of site can be calculated.

1.4 Objectives

The objectives of this project are related to the implementation of tidal power plant and feasibility study of the proposed sites. The objectives of this project are:

1. To investigate water head of Kuching Barrage to propose a suitable tidal power plant scheme
2. To investigate water flow rate at Kuching Barrage to propose a suitable tidal power plant scheme
3. To estimate annual energy output from Kuching Barrage tidal power scheme
4. To proposed a suitable powerhouse design for Kuching Barrage tidal power scheme

1.5 Scope of Project

This project is proposing Kuching Barrage, Sarawak as the site of study for tidal range technologies. Kuching Barrage began its construction in 25th July 1995 and starts operation in 1998 (Sarawak Rivers Board, n. d.). The construction of the barrage is as a flood mitigation project of Sarawak capital, Kuching which is a flood prone area. Kuching Barrage consists of five radial gates controlled hydraulically with the width of 25m and 12 m tall. The radial gates are use to control the level of water at the upstream of the barrage.

Data of the site is to be obtained from previous research of the barrage. Information on the technical details of Kuching Barrage, shiplock and bridge will also be use for the proposal of tidal power plant at Kuching Barrage. Dimensions and physical parameters of the barrage are critical for the installation of selected tidal turbine.

CAD software is to be use to visualise the proposed tidal power plant scheme at Kuching Barrage. Visualisation of the proposed tidal power plant is to aid on understanding the operation of turbine and the structural design of this project.

1.6 Significants of Project

The benefits and expectation from this project are:

1. The data gathered on Kuching Barrage will be helpful for other related study on the barrage in the future
2. The proposed tidal power plant scheme can be a bench mark or reference for similar project proposal
3. This project is to introduce and promote energy harnessing from tides which is relatively new in Malaysia’s renewable energy resources

1.7 Hypothesis

Data from previous studies on Kuching Barrage and flood mitigation in Sarawak River is used to investigate the tidal parameters of the proposed site. The parameters are water head and flow rate of Kuching Barrage. This project will find out the starting water head and minimum water head of Kuching Barrage. Flow rate and annual power output of the proposed tidal turbine will also be calculated theoretically.

Technical details of Kuching Barrage will be use for designing the proposed tidal power plant. CAD software is use to visualise the design of the barrage. The visualisation is to further help structural understanding of the proposed tidal power plant.

1.8 Structure of Thesis

Chapter 1

The chapter consist of a brief introduction and motivation of the low and high tide harvesting technology project as well as the main objective of the project. Apart from that, problem statements, scope, significant and hypothesis of this project is also included in the particular chapter.

Chapter 2

Chapter 2 is specifically for literature reviews of tidal range technology for energy harnessing and the related issues regarding the technology. A brief history and process of energy harnessing of tidal range technology is also explained in the chapter. The chapter will further discuss the limitation or problems in implementing tidal barrage projects.

Chapter 3

Methodology of this project will be explained in the chapter. The prospect and parameters of the proposed site are discussed in the chapter. The chapter will also include the method for head, water flow rate and annual power calculations.

Chapter 4

The chapter will state and discuss the key finding of this project. Engineering drawing of the proposed tidal power plant is also explained and shown in this section.

Chapter 5

This chapter wraps up findings and state the limitation of this project. Further recommendations are also included for future improvement of this project.

CHAPTER 2

LITERATURE REVIEW

2.1 Formation of Low and High Tides

Tide is formed by the movement of Earth and Moon around each other and as the Earth orbits around the Sun. The gravitational force of the Earth that attracts the Sun and the Moon causes differences in height of the sea level and these differences are known as tides (Leclercq, 2012). The distance of the Moon to Earth is much shorter compared to the distance of the Sun to Earth and this result in Moon having force more than twice on the tides (Gorlov, 2011). The force is known as gravitation force and is given by equation (1) that shows the relation between gravitation force and distance between masses is inversely proportional. The mass difference between the Moon and the Sun does not greatly affect the magnitude of gravitation force since the Moon is much closer to the Earth (Chang, 2008).

Rotation of the Moon around the Earth greatly affects tide formation creating diurnal tide and ebb cycles on the ocean surface. Ebb cycle is when sea water at bay or estuary starts ebbing and this occurs as the Moon began to travel further over the land thus the occurrence of low tides. High tides occur as sea water starts flooding bay or estuary. The height difference between the low and high tides is known as tidal range. The potential energy of the tidal range is use as the driving force to move turbine blades.

Figure 2.1: Tidal pattern in Malaysia (Lee & Seng, 2009)

$$F_{grav} = \frac{Gm_1 m_2}{d^2} \quad (1)$$

Where

F_{grav} = Gravitation force (N);

G = Universal gravitation constant (6.673×10^{-11} Nm^2/kg^2);

m_1 = the mass of the Moon or Sun (kg);

m_2 = the mass of the molecule of water (kg);

and

d = the distance of the water molecule from the Moon or Sun (m).

Tide is divided into three types that are semidiurnal tides, diurnal tides and mixed tides (Hammons, 1993). Semidiurnal tides have the occurrence of low and high tides twice a day. On the contrary, diurnal tides only consist of one low and high tide in a day. Mixed tides are the combination of both semidiurnal tides and diurnal tides with two uneven low and high tides in a day. These tides phenomena occur periodically and its tidal pattern can be predicted. The tidal pattern of a potential tidal power plant site also has a significant effect on power generation. According to McCarthy and Murray (2014), site with semidiurnal tides has the peak level occurring twice a day is the most efficient tidal pattern. Hence, site with semidiurnal tides can generate power twice in a day. Figure 2.1 shows the tidal pattern of Malaysia and Sarawak tidal pattern is consists of mixed tides with dominant semidiurnal and mixed tides with dominant diurnal. The proposed tidal power plant of this project is located in Kuching, Sarawak with mixed tide with dominant semidiurnal tidal pattern. The stated tidal pattern reaches highest