

**DESIGN AND DEVELOPMENT OF UNDERWATER THRUSTER
FOR AUTONOMOUS UNDERWATER VEHICLE (AUV)**

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**BACHELOR OF MECHATRONICS ENGINEERING WITH
HONOURS
UNIVERSITI TEKNIKAL MALAYSIA MELAKA**

2019

**DESIGN AND DEVELOPMENT OF UNDERWATER THRUSTER FOR
AUTONOMOUS UNDERWATER VEHICLE (AUV)**

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**A report submitted
in partial fulfilment of the requirements for the degree of
Bachelor of Mechatronics Engineering with Honours**

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2019

DECLARATION

I declare that this thesis entitled “DESIGN AND DEVELOPMENT OF UNDERWATER THRUSTER FOR AUTONOMOUS UNDERWATER VEHICLE (AUV) ”is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :

Name : GRACE WONG MEE SING

Date :

APPROVAL

I hereby declare that I have checked this report entitled “DESIGN AND DEVELOPMENT OF UNDERWATER THRUSTER FOR AUTONOMOUS UNDERWATER VEHICLE (AUV)” and in my opinion, this thesis it complies the partial fulfillment for awarding the award of the degree of Bachelor of Mechatronics Engineering with Honours

Signature :

Supervisor Name :

Date :

DEDICATIONS

To my beloved mother and father

ACKNOWLEDGEMENTS

I am GRACE WONG MEE SING as an undergraduate student from University Teknikal Malaysia Melaka (UTeM). In preparing this report, I would wish to show my greatest admiration and deepest gratitude to my supervisor, DR. Mohd Shahrieel Bin Mohd Aras for his patient, guidance, encouragement and valuable advice during this project. His methodical approach to problem-solving and encouraging words always filled me with optimism, vitality and enthusiasm. Still, his leadership and guidance made it a neat learning experience for me.

Also, I would like to offer my grateful thanks to my panel DR. Saifulza bin Alwi @ Suhaimi and DR. Rozaimi bin Ghazali for their patient and encouraging words. My grateful thanks also extended to Professor Madya Dr. Ahmad Zaki bin Shukor and also University Teknikal Malaysia Melaka (UTeM) for offering me resources in running the program during the Final Year Project.

ABSTRACT

In the underwater research, Autonomous Underwater Vehicle (AUV) and Remotely Operated Vehicle (ROV) are created to assist human due to the efficiency, safe approach and lower operating cost. AUV was an Unmanned Underwater Vehicle with simply computer-control system operating underwater and thruster is one of the important parts which is for moving mechanism in the water and allow the AUV to submerge. The cost for developing the thruster is expensive and it is no fixed procedure to design the thruster based on the propeller design such as size and number of blades of the propeller. Thus, this project is focused on the design and development of the affordable, easy to fabricate and can produce high thrust underwater thruster. In designing the underwater thruster, SolidWorks software is used to design and undergoes stress and strain test. Hardware that discusses and included propeller, nozzle, type of motor and submersion that achieve a certain performance in terms of speed and thrust. Propeller which design in 30 degrees and with two, three, four and five blades. Nozzle design also follow the Kort design to produce high thrust for the thruster. Type of the motor used are A2212 dc brushless motor, D2830 power series dc brushless motor, M100 and M200 for comparing the thrust and speed for the motor. D2830 has the highest speed when compare to others type of motor which means that D2830 have higher speed than others. AUV used thruster to move in pitch, raw and yaw direction by using programming code. The analysis for the thruster can be recorded which is speed, thrust, stress and strain. A2212 DC brushless motor has cheapest price and the speed also approximate to the D2830 DC brushless motor.

ABSTRAK

Dalam penyelidikan bawah air, Kenderaan Bawah Air Autonomi (AUV) dan Kenderaan Bergerak Di Bawah Tanah (ROV) diwujudkan untuk membantu manusia kerana kecekapan, pendekatan yang selamat dan kos operasi yang lebih rendah. AUV adalah Kenderaan Bawah Air yang tidak dikendalikan dengan hanya sistem kawalan komputer yang beroperasi di bawah air dan pembusukan adalah salah satu bahagian yang penting untuk mekanisme bergerak di dalam air dan membenarkan AUV untuk menenggelamkan. Kos untuk membina penebat adalah mahal dan tidak ada prosedur tetap untuk merancang penebat berdasarkan reka bentuk kipas seperti saiz dan bilangan bilah kipas. Oleh itu, projek ini memberi tumpuan kepada reka bentuk dan pembangunan yang berpatutan, mudah untuk menghasilkan dan boleh menghasilkan tusukan bawah air yang tinggi. Dalam merekabentuk pencuri bawah air, perisian SolidWorks digunakan untuk merekabentuk dan menjalani ujian tekanan dan ketegangan. Perkakasan yang membincangkan dan termasuk kipas, muncung, jenis motor dan penyerapan yang mencapai prestasi tertentu dari segi kelajuan dan teras. Propeller yang direka dalam 30 darjah dan dengan dua, tiga, empat dan lima bilah. Reka bentuk muncung juga mengikuti reka bentuk Kort untuk menghasilkan tujahan tinggi untuk pemancet. Jenis motor yang digunakan ialah motor brushless A2212 dc, motor D2830 siri kuasa tanpa motor, M100 dan M200 untuk membandingkan tujahan dan kelajuan motor. D2830 mempunyai kelajuan tertinggi apabila dibandingkan dengan jenis motor yang lain yang bermaksud bahawa D2830 mempunyai kelajuan yang lebih tinggi daripada yang lain. AUV menggunakan pemalut untuk bergerak di padang, mentah dan hala dengan menggunakan kod pengaturcaraan. Analisis untuk pencungkil boleh direkodkan iaitu kelajuan, tujah, stres dan ketegangan. Motor brushless DC A2212 mempunyai harga termurah dan kelajuan juga berkisar kepada motor brushless DC D2830.

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LIST OF SYMBOLS AND ABBREVIATIONS

UTeM	-	University Teknikal Malaysia Melaka
AUV	-	Autonomous Underwater Vehicle
ROV	-	Remotely Operated Vehicle
UUV	-	Unmanned Underwater Vehicle
ESC	-	Electronic speed controller

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CHAPTER 1

INTRODUCTION

1.1 Introduction

The earth is a watery place. Figure 1 shows the Earth's surface is covered by the water which is about 71 percent out of 100 percent. [1] Ocean is a continuous body of the saltwater that covers 96.5 percent of all Earth's water. [2] Ocean is divided into four major section by geographers which are Pacific, Atlantic, Indian and Arctic. Seas, gulfs and bays such as the Mediterranean Sea, Gulf of Mexico and the Bay of Bengal are stated as smaller ocean region. [3] Ocean is the place that life began and remains home to the majority of Earth's plants and animal. The ocean remains one of the most expansive, mysterious and diverse places on Earth. Nowadays, activity-activity that carries out by human impact nearly all parts of the ocean. [4] These activities affect the whole oceanic ecosystem which threatened by various sources of pollution. [5] First and foremost, plastic pollution is one of the pollutions that affect the oceanic ecosystem.



Figure 1.1: Earth's surface

Figure 1.2 shows that the plastic pollution has become a global crisis. The statistic shows that billions of pounds of the plastic that make up about 40 percent of the world's ocean surface can be found in swirling convergences. Thousands of seabirds, sea turtles and other marine mammals are entangled in plastic and accidentally ate the plastic. [6]



Figure 1.2: Plastic pollution on the ocean.



Figure 1.3: Oil pollution in the ocean.

Besides, large reserves of oil and gas trapped deep beneath the earth's surface. Oil and gas seep out at these reserves develops cracks and this phenomenon rarely causes any major damage. Human interference can cause a great deal of damage to marine ecosystems. Offshore drilling operations can cause oil waste and pollute the ocean due to flowline and pipeline leaks and disposal of oil-based drilling fluid wastes. [7] Phenomenon water whirl is swirling at a velocity of over 20mph and it have a diameter of over 65 feet. [8] This phenomenon in the ocean is dangerous for diver which can make it hard for even the most skilled of diver. [10] Through this phenomenon and the pollution in the ocean, Autonomous Underwater Vehicle (AUV) or Remotely Operated Underwater vehicle (ROV) need to be implemented to solve this problem.

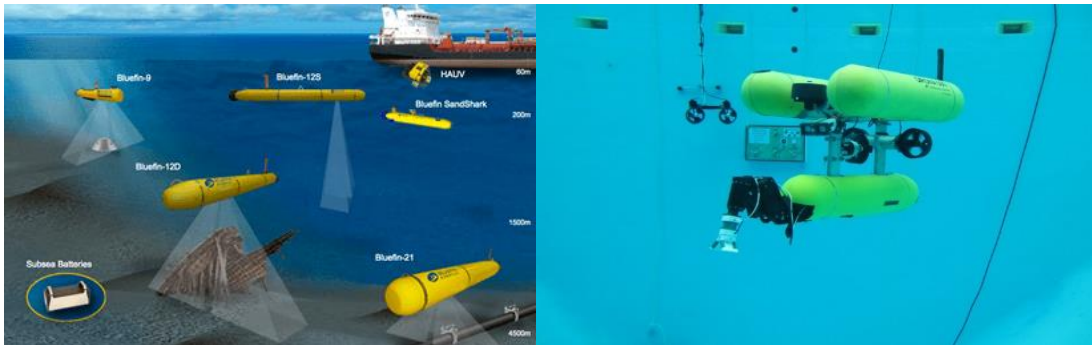


Figure 1.4: Autonomous Underwater Vehicle.

Autonomous Underwater Vehicle (AUV) is commonly known as an unmanned underwater vehicle which operates independently from the ships and has no any cable connected to it. [11] AUV is a programmable robotic vehicle without real-time control of human operators which can drift, drive and glide depends on their design. [11] AUV offers numerous advantages over offshore survey platforms. For deep sea field development and seabed mapping, oil and gas industry utility sector or government agencies can use AUVs to collect high resolution data. Besides, AUVs are used in shallow water for ports and harbor surveys and offshore wind sector. [12]

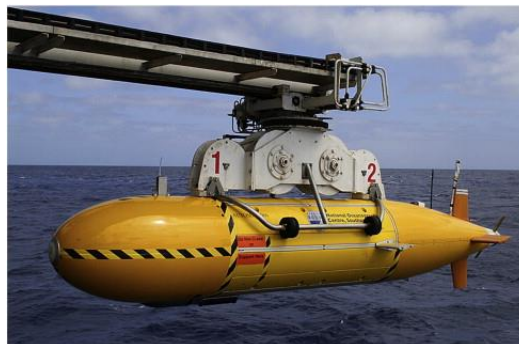


Figure 1.5: AUV that standby for research purpose.

Human diver and boat have limitation at the deeper and shallower water. Thus, AUVs are implemented to save the diver's life and able to collecting data at a very high data-to-signal ration. [13]



Figure 1.6: AUV thruster for moving forward, backward, downward and upward.

Underwater robot, Autonomous Underwater Vehicle (AUV) and submarine needs electrical underwater thruster which produces electric propulsion to move in the water. This electrical thruster is fitted with a motor and propeller which is an electromechanical device that generates the thrust to move the underwater vehicle. [14] Generally, thrust force is affected by motor model, the design of the propeller and the number of blades. Thruster modelling is important in controlling the AUV. This is because the lowest control loop of the system would benefit from accurate and practical modelling of the pusher. The kinetics of the thruster dominate the control problem and must be properly considered to receive exact solutions. [15] The operation of the thruster is greatly influenced by thruster design such as axial and cross-flow effects nonlinearities related to thruster dynamic behavior which is important and influence overall system behavior in a way fundamentally different from most hydrodynamic and inertial nonlinearities. The dynamics of the thrusters dominate the behavior of the vehicle by restricting the maximum closed-loop bandwidth and creating a limit cycle.

1.2 Motivation

According to Free Malaysia Today, the divers were looking for a 17-year-old boy who had fallen into a mining pond in Taman Putra Perdana, Puchong. Abdul Aziz Ali, who is district police chief Assistant Commissioner at Sepang mention that during the operation, the divers were caught in strong whirlpool. [16] Through this new, AUV or ROV are very important to observe the situation in the water. Thus, this project is used to develop an AUV and thruster for the AUV, which are the most important part for the AUV to move forward, backward, downward and upward.

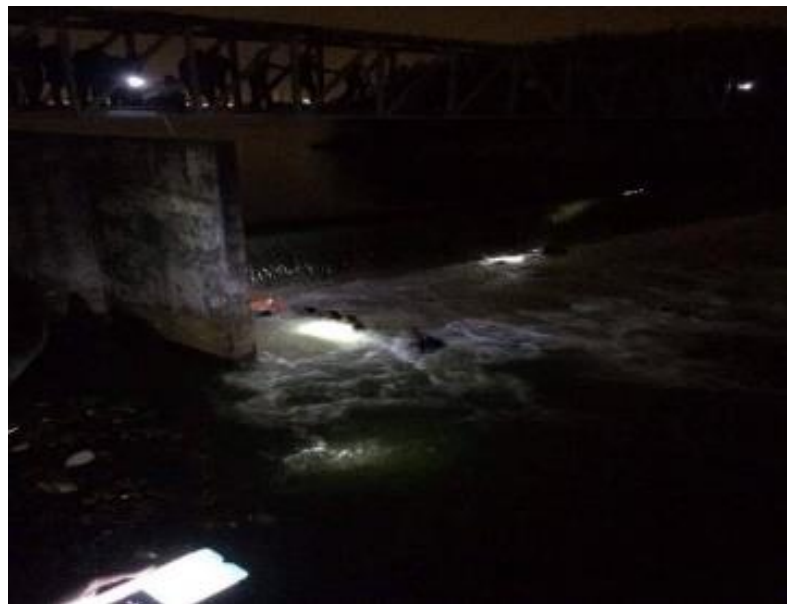


Figure 1.7: Divers who are trying to save the 17-year-old boy.

There are many facts that need to consider which make the modelling procedure difficult. Appropriate motor alternatives are chosen through a process of elimination assisted by a computerized script based on extensive propeller series. Propeller and motor which used in a hostile environment such as ocean, corrosion and other external influences which may cause damage to the system must consider in the design. Thus, the consequence of this project design and develop the versatile underwater thruster with low cost, high performance and high quality to commercialize and to research purposes. The paper starts with design and fabricate the thruster and common movement control.

1.3 Problem Statement

There are some of the problem statements that need to be considered in design and develop the underwater thruster. There is no any procedure in design and develop the propeller and duct for the thruster. The performance of the thruster is hard to determine, based on the speed, thrust and power. Also the size, diameter and the angle of the propeller is not stated clearly for designing the propeller. Furthermore, the size of the thruster needed to be considered to have high efficiency.

There is an important thing that need to learn are constructed of the thruster, type of propeller and type of motor. Construction of the motor need to be learned to know the design, function and how the thruster work. The propeller is one of the important parts in the thruster. The static and dynamic efficiency of thruster increases when the propeller is mounted in a duct or shroud. Moreover, the diameter of the propeller can influence the amount of thrust available for propulsion by determining the amount of power that the propeller can absorb and deliver. Furthermore, there are few parameters that need to be learned during analysis, which are speed of the thruster, thrust produced by the propeller and power that need to be optimized. Thrust that produced by the propeller is depend on the diameter and the angle of the propeller. The speed of the thruster depends on the torque of the motor and the type of the motor used. Type of the motor is needed to consider so that the high efficiency of the motor has been chosen to produce high torque and give faster speed to thruster.

In short, these are the problem that needs to be considered in the FYP so that it can achieve the objectives.

1.4 Objective

There are three objectives that need to achieve are to:

- i) Design and analysis of the underwater thruster for Autonomous Underwater Vehicle (AUV) by using SolidWorks.
- ii) Develop and fabricate the underwater thruster for Autonomous Underwater Vehicle (AUV).
- iii) Investigate the performance of thruster in terms of thrust produced, propeller with difference numbers of blade and speed of the thruster.

1.5 Scope

The thruster is important for AUV that can move and submerge in the water. Configuration of the thruster needs to learn to develop the thruster. SolidWorks software is used to design the thruster and run flow simulation and some testing. The diameter of the propeller and number of blades needs to be considered for the design so that it can produce large propulsion or high thrust for moving the AUV. Furthermore, thruster must be designed and developed with safety, efficiency and power. Moreover, the type of the motor is an important component that produces torque to move the propeller.

- a) Solidwork software is used to design and analysis.
- b) The voltage of the power source used by each thruster should be less than 24V.
- c) The electronic part used microcontroller Arduino Uno and Raspberry Pi.
- d) Thruster must have high thrust, efficiency and safety.