"I hereby declare that I have read through this report entitle "Development of Unmanned Surface Vehicle" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Mechatronics Engineering"

Signature **:** ……………..

Name **:** Dr. Mohd Shahrieel Mohd Aras

Date **:** ....

DEVELOPMENT OF UNMANNED SURFACE VEHICLE

ONG CHEAH HOW

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

Faculty of Electrical Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2016

I declare this report entitle “Development of Unmanned Surface Vehicle” is the result of my own research except as cited in references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……………...

Name : ONG CHEAH HOW

Date : ....

To my beloved mother and father

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ABSTRACT

Unmanned Surface Vehicle (USV) is a type of vehicle that can be categorized in Remotely Operated Vehicle (ROV) class. The range of application for USV is very wide including marine rescue, surveillance, seabed mapping and military uses. The USV is a vehicle that is able to adapt to various mission by installing the specific equipment or hardware. The problems faced during the fabrication of USV are manoeuvrability, stability and speed. This project is about developing an USV that can perform seabed mapping mission. The USV built have to be small scale and low cost. Besides that, the USV should be able to control in a certain range and have a good battery life. In designing the USV, Solidworks^{TM} software is used and then the design of USV undergoes various simulation tests such as stress test, displacement test and flow simulation. Next, the hardware that selected such as brushed DC motor, propeller and rudder should be able to drive the USV and achieve a certain performance in terms of manoeuvrability, power and control. The USV undergoes a series of field test at the end to evaluate its ability and performance in seabed mapping mission. In buoyancy test, the results obtained shows that the additional floats had increased the buoyancy force of the USV which in turn increased the payload can be carried by USV. The USV is considered as slightly unstable when equipped with floats and components but with extra weight attached on USV, it helped to balance it and the USV is able to travel straight. Speed of USV was also fast enough to carry out seabed mapping mission. Lastly, the USV successfully carried out its seabed mapping mission in a 10 m x 10 m area at Tasik Ayer Keroh.

ABSTRAK

Kenderaan Permukaan tanpa Pemandu (USV) adalah satu jenis kenderaan yang boleh dikategorikan dalam kelas kenderaan kawalan jauh (ROV). Aplikasi bagi USV adalah sangat luas termasuk misi penyelamat laut, pengawasa, pemetaan dasar laut and kegunaan tentera. USV juga adalah satu jenis kenderaan yang mampu menyesuaikan kepada misi yang berlainan jenis dengan pemasangan alatan yang tertentu. Masalah yang dihadapi semasa fabrikasi USV adalah cara mengerakkan USV, kestabilan dan kelajuan. Tujuan projek ini adalah untuk membangunkan satu USV yang boleh melaksanakan misi pemetaan dasar laut. Selain itu, USV yang dibina hendaklah dalam kos yang rendah dan scala yang kecil. USV juga haruslah dikawal dari jarak yang tertentu dan mempunyai hayat bateri yang bagus. Solidworks^{TM} adalah perisian yang digunakan untuk mereka bentuk USV dan akan menjalani ujian simulasi seperti ujian tekanan, ujian anjakan dan simulasi aliran. Seterusnya, perkakasan seperti DC motor berus, kipas dan kemudi perlu dipilih dan seharusnya dapat memandukan USV dan mencapai satu tahap prestasi dari segi cara menggerakkan USV, kuasa dan kawalan. Akhirnya, USV yang dibina akan menjalani beberapa ujian lapangan untuk menilai prestasi dan keupayaannya untuk menjalani misi pemetaan dasar laut. Keputusan yang diperolehi dalam ujian keapungan menunjukkan tambahan pelampung telah meningkatkan daya keapungan dan muatan USV. USV tidak stabil setelah dilengkapkan dengan pelampung dan komponen tetapi berat tambahan dilampirkan atas USV menstabilkan USV agar USV boleh jalan dalam arah lurus. Kelajuan USV juga cukup pantas untuk menjalankan misi pemetaan dasar laut. Akhir sekali, USV yang dibina berjaya menjalankan misi pemetaan dasar laut dalam kawasan 10 m x 10 m atas Tasik Ayer Keroh.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

In recent years, the unmanned surface vehicle (USV) was seen in a rapid growth and is considered as one of the popular category in marine transportation. The unmanned surface vehicle (USV) has also been called autonomous surface craft (ASC). The USV removed the operators or crew from the platform; therefore this type of vehicle was named as unmanned surface vehicle. The USV can be controlled either autonomous or manually by the operator from distance away. Fast development of systems such as global positioning system and wireless data systems had contributed for the rapid growth on USVs for various applications. Figure 1.1 showed the example of USV. For better understanding, the development of unmanned surface vehicle is explained as in the journal [1].

Figure 1.1: Example picture of USV

Basically, the platform design of USVs consisted of few types such as mono-hull, catamaran, trimaran and hovercraft. USVs normally were propelled by using either thruster under surface water or above surface water. For hovercraft case, it moved with a thruster and cushion of air under the hull. Steering of the USVs was done with the installation of rudder behind the thruster. Figure 1.2 showed the example of hovercraft and USV.

Figure 1.2: Example picture of hovercraft on the left and USV on the right

Under the MIT Sea Grant College Program, Autonomous Surface Craft (ASCs) were first developed in 1993. The first ASC produced under this program was named ARTEMIS. This ASC was then used to collect simple bathymetry data in the Charles River in Boston, MA. In the earlier stage of development, the USV possessed a major problem which was its small size. Smaller in size means the endurance and seakeeping were limited. With the continuous development, the USVs have grown into a more stable transport on the water. It can now adapt to various mission and applications. The major uses of USVs included research on sea, defense, survey, rescue and surveillance activities. In future, the USVs may achieve longer endurance and it is possible to envision a new era of ocean observing. This will benefit a lot of scientific and military missions by using long range USVs. Wider adoption of USVs may lead to reduced capital costs and thus additional applications of the technology.

1.2 Motivation

First and foremost, the final year project is compulsory to complete within two semesters to fulfillment the requirement for award the degree of Bachelor Mechatronics Engineering. The reason that I choose to design and fabricate an unmanned surface vehicle (USV) as my final year project is because I am personally more interested in the marine application field.

As we have known, Malaysia is still lacking in terms of marine technology compared to the other countries. But, marine technology can benefit to our country in many aspects for example improving safety of Malaysia's sea area. Moreover, recently Malaysia has suffered from the invasion of pirate especially in Sabah and Sarawak. The main reason why Malaysia is targeted is because of lack of patrol from the marine police. Frequently patrolling required a high demand of manpower but with the development of unmanned surface vehicle (USV), the problem can solve easily. USV can be controlled from distance away and it can guarantee the safety of the crew. The police or crew can use USV to obtain the vision of the sea without present in there. Moreover, USV is suitable for other application such as survey, data collecting, rescue, and surveillance mission.

The news of MH370 crashed into the ocean has also alert the importance of development in unmanned vehicle category such as unmanned surface vehicle (USV). The whole world had spent a hundred or thousand million dollar for the rescuing mission. The rescue mission is mostly done by the unmanned marine vehicle because the waves are too big and possess danger to human. We can see a lot of news report that developed countries such as America has deployed advance underwater or surface marine vehicle for rescue mission whereas Malaysia is still in the process of development in this field.

In conclusion, the development of unmanned surface vehicle in Malaysia is still trailed behind the developed countries and there are a lot of efforts needed to accelerate the development of this field in Malaysia.

1.3 Problem Statement

The aim of this project was to design and fabricate a small-scale working model of an Unmanned Surface Vehicle (USV) with dimension included. The risk of continuous staying on the sea or river is higher for humans. A lot of environment factors such as weather, big wave, fast current may affect the crew's safety and the efficiency of certain missions. Therefore, problem exists in how to make the body of USV to become stable and not easily damage. Another problem exists is the difficulty of human to carry out seabed mapping mission for a long period of time. Existence of USV can help to solve this problem but another issue is how big the power consumption required by USV to perform unmanned seabed mapping mission for certain period.

Application of USV in seabed mapping mission required the USV to maintain certain speed on the surface water. Thruster is the one that provide thrust to the vehicle. Many factors affect the thrust produced by thruster. For example, the type of propeller and the specification of the propeller such as pitch diameter and number of blade. The external factor such as air density, air temperature, water density and load of vehicle itself also affect the thrust produced. Cornering angle of USV is one of the problems affected by speed of USV. Fast development of systems such as global positioning system and wireless data systems had contributed for the rapid growth on USVs for various applications. But, communication between USV and platform is proved to be another issue to be solved.

In journal [2], the unmanned surface vehicle is used for multi mission application. The USV is tested with various applications such as harbor surveillance, water quality sampling, maritime search and rescue. Moreover, the unmanned surface vehicle is tested applicable also for sea patrol and environmental monitoring in journal [3] and another journal [4] discussed about the modeling and control of an unmanned surface vehicle for environmental monitoring.

In conclusion, idea of this project is to design a low cost and small scale USV that can operate without crew. In addition, the vehicle should be able to perform basic function of USV, seabed mapping ability and provided with vision came from camera mounted on it.

1.4 Objectives

The main objectives of this project are listed as follow:

1. To design and fabricate one type of architecture platform together with thruster suitable for the vehicle to travel on the surface water.
2. To design and develop a small scale unmanned surface vehicle (USV) for seabed mapping purpose.
3. To test and analyze the performance of USV in term of controllability, maneuverability and stability.

1.5 Scope

The scopes and limitations of this project are:

1. The range of control for USV is less than 260 m.
2. Speed of the USV achieved is slower than 30km/h (8.333 m/s).
3. The USV is controlled by using 2.4 GHz radio control.
4. The mounted camera can capture picture and record video for up to 10 minutes
5. The USV is tested on Tasik Ayer Keroh.

1.6 Summary

As a summary, chapter 1 introduced about the background of the whole project. The background of the project consists of history of USV, past application of USV and some pictures of USV. Next, the problems faced during the progress are identified and were listed out in problem statements. The main problems that I faced was how to build a low cost and small scale USV by considering other factors such as body design and thruster design. Besides that, the reasons and motivation behind that drive me to complete this final year project also listed in chapter 1. Last but not least, the objectives and scopes to be achieved are stated in the last part of chapter 1.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In literature review, journals and papers of previous work is being reviewed. All the important of experimental result, data or findings is being synthesized and summarized in this chapter. For the analysis of the information obtained, this chapter focused based on 2 main criteria. The first criteria to be studied are on the design architecture of the platform vehicle design while the second criteria are the design of the thruster.

2.2 Factors Affects the Design of USV

In overall, there is several parameter or factors that have to be considered during the designing of an USV. Platform design was the factor that has to be considered when designing the body of an USV. For example, a catamaran USV is safer to travel on rough condition water surface than a mono-hull USV. The motor or type of thruster used were the another factors that affects the speed and manoeuvring ability of an USV. Thruster system with dual motors were expected to provide more thrust to the USV for traveling in rough condition water surface than only one motor to provide thrust. Propeller was another factor that affects the thrust created from the motors. For steering purpose, different type of rudder design provided different steering effect on the USV. The last factor to be considered is the buoyancy of the USV. The buoyancy was calculated or determined based