DESIGN OF HYDRODYNAMIC BODY STRUCTURE FOR AUTONOMOUS UNDERWATER VEHICLE APPLICATION

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A report submitted in fulfillment for the degree of Bachelor of Mechanical Engineering (Hons)

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DECLARATION

I declare that this project report entitled "Design of Hydrodynamic Body Structure for Autonomous Underwater Vehicle Application" is the result of my own work excepts cited in the references.

Signature	:	……………………………..
Name	:	……………………………..
Date	:	……………………………..

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Hons).

Signature : ……………………

Supervisor's Name : ……………………

Date : ……………………

DEDICATION

Special dedication to my beloved mother, Fuziah binti Mohd Sharif and my lovely father, Abdul Bari bin Abdullah.

ABSTRACT

Singapore Autonomous Underwater Vehicle Challenge (SAUVC) is an event organized IEEE Oceanic Engineering Society that took place in Singapore. This competition delegate a valuable project where it combine academic work and learning with practical skill development engineering. In building and designing the AUV, the critical component that should be taken into consideration is body structure. Objective of this project is to produce a design concept that can be used to compare to the existing design. Software used in this project is CATIA V5R16 for Computer Aided Design and using Ansys Fluent for Computational Fluid Dynamics. There are 5 concepts that had been proposed in this project and the selection method used to select the champion concept is using Pugh's Selection Chart and Weighted Decision Matrix. After choosing the champion concept, that it will be proceed on 3D modelling and analysis on the body structure. The analysis is chosen based on the vector field, streamline, and contour and drag/lift coefficient and based on this analysis, the new and existing design will be compared and determined which design would be more suitable to be used in the next SAUVC event.

ABSTRAK

Singapore Autonomous Underwater Vehicle Challenge (SAUVC) adalah satu acara yang dianjurkan oleh IEEE *Oceanic Engineering Society* yang diadakan di Singapura. Pertandingan ini merupakan sebuah pentas untuk menunjukkan kemahiran wakil peserta dari seluruh dunia menggabungkan kerja akademik dan kemahiran praktikal kejuruteraan dalam bidang AUV. Dalam proses pembinaan dan reka bentuk AUV, terdapat komponen yang kritikal yang perlu dititik-beratkan iaitu struktur badan. Objektif projek ini adalah untuk menghasilkan konsep reka bentuk yang boleh digunakan untuk perbandingan dengan reka bentuk sedia ada, iaitu Panther AUV. Perisian yang digunakan dalam projek ini adalah CATIA V5R16 untuk Lukisan Berbantu Komputer dan Ansys Fluent untuk Pengiraan Dinamik Bendalir. Dengan bantuan kaedah reka bentuk, terdapat 5 reka bentuk konsep yang telah dicadangkan dalam projek ini dan menggunakan kaedah pemilihan yang seperti Carta Seleksi Pugh dan Matrik Keputusan Tertimbang untuk memilih konsep juara. Konsep ini akan diteruskan untuk permodelan 3D dan analisis ke atas struktur badan. Analisis ini dilakukan terhadap dua AUV yang akan dibandingkan dan dipilih menerusi keputusan terbaik daripada beberapa analisa seperti medan vektor, garis aliran, kontur dan seretan/angkat pekali. Reka bentuk yang terbaik akan dipilih untuk digunakan dalam acara SAUVC yang akan datang.

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Alhamdulillah, thanks to Allah S.W.T for giving me the opportunity in life and allowed me to finish this report and project. Deep in my heart, I also want to thank my parents that are always pray for me and never tired on supporting me on my path to becoming an engineer.

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ROV	Remotely Operated Underwater Vehicles
AUV	Autonomous Underwater Vehicles
CAD	Computer-Aided Design
CFD	Computational Fluid Dynamics

CHAPTER 1

INTRODUCTION

1.0 Background

Underwater vehicles still playing a vital role in underwater exploration and allowing humans to explore great depths of the maritime world. Remotely operated underwater vehicles (ROVs) have been used in the offshore industry since the late 1960s and are well established and specialized vehicles for deep-water missions. But ROV has a constraint such as the need for a communications tether and a control platform have limited their use and capabilities as shown in Figure 1.1.

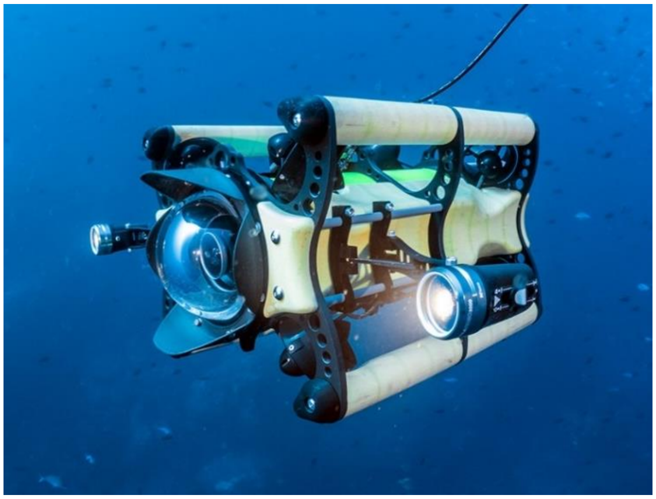

Figure 1.1: Remotely operated underwater vehicle (ROV)

(Source: https://pureadvantage.org/wp-content/uploads/2016/11/Boxfish_ROV_dive_3.jpg)

To overcome the disadvantages of ROV, autonomous underwater vehicles (AUVs) have become the new method to explore the depth of the ocean. AUV is untethered, fully automated submersible vehicle that can perform underwater tasks and missions with their onboard sensor and navigation. AUV has come a long way from the ROV in terms of programming and the development of the vehicle. That’s why the AUV has become the centerpiece in this section rather than ROV despite its complexity of the design and its programming.

Figure 1.2: Autonomous underwater vehicle (AUV) *(Source: https://gdmissionsystems.com/-/media/General-Dynamics/Maritime-and-Strategic-Systems/Bluefin/Images/bluefin-sandshark-carousel-1.ashx)*

AUVs are not merely restricted to scientific underwater exploratory applications. They are also used for military purposes, an inspection of underwater structures, as well as being largely utilized in the mining and oil industries. For example, Figure 1.2 shows an AUV that has been developed by General Dynamics for the military in the United States. Many countries have intensive AUV research and development programs. This is a clear indication of the growing importance and significance of these vehicles.

Every AUV has its own navigation system, propulsion system, and a dry, watertight environment to house onboard components. All component work simultaneously with each other. As an example, from Figure 1.3, the battery packs powered up all the components in the AUV. The DVL units and the GPS are for the navigation system, the thruster is for the movement of the AUV and the main hull containing all the electronic parts that control all these components. In addition, an AUV will usually have the following systems and components as seen in Figure 1.3.

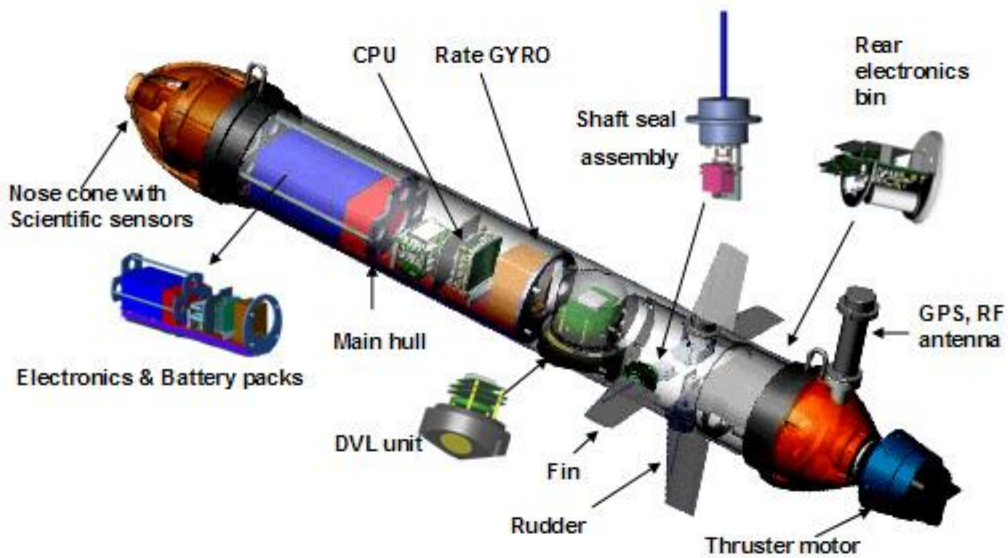

Figure 1.3: AUV systems and components. *(Source: http://www.nio.org/userfiles/image/images/exploded_AUV.jpg)*

Nowadays, many universities all over the world are doing research on AUV. The task of designers was to develop a concept for an AUV which is smaller and cheaper than the commercial ones. There is a lot of AUV that has been developed have the torpedo-shaped which is for stealth and compact to generate less drag to the surface. This torpedo-shaped AUV has less modularity and can consume time to assemble and disassemble the individual parts. Figure 1.4 show BlueROV2 that have modularity on the parts which can be easily replaced and debugged if one of the components damaged. This can help reduce the time to assembling the ROV itself.

Figure 1.4: BlueROV2 by Blue Robotics. *(Source: https://www.bluerobotics.com/wp-content/uploads/2016/06/BlueROV2-4-lumen-1.png?x68454)*

1.1 Problem Statement

Most commercial AUV on the market has a robust design and ignoring the aerodynamic characteristic which can cause reduce speed and stability. To compensate for the robust design these commercial design, having a modularity aspect to an AUV can help a lot in reducing component's cost if damage and to replace it will be easier. This project makes possible to come up with a solution on the design which has the aerodynamic body structure without sacrificing the modularity of the components.

The challenge of this project is to develop an aerodynamic body structure of the AUV that is better than its predecessor which is the Panther AUV. By using Computational Fluid Dynamics software to compare the data collected of both designs which are the main purpose of this project. The current design did not have the best hydrodynamically stable on its design that will be mention in the next chapter.

The obstacle of this test also is to reduce the drag force to ensure the rigidity and stability of the movement of the AUV. This obstacle is essential to this project because by reducing the drag force on the body structure, there should be an increase in speed and stability for the vehicle.

1.2 Objective

The objectives of this project are as follows:

1. To compare the movement speed and stability of the AUV with existing design when operating underwater.
2. To be used in the Singapore Autonomous Underwater Vehicle Challenge (SAUVC) event.

2.3 Scope of Project

The scopes of this project are:

1. To design a hydrodynamic body structure for AUV by using CAD.
2. To analyze the rigidity and stability of the body structure by using analysis software.
3. To compare the rigidity and stability with existing body structure design.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

The background of this study needed to be studied to have a better understanding before indulging the methodology process. In this chapter, relevant topics under the scope of this research are collected and reviewed. These researches are related and most are from journals, articles and academic books.

This chapter consists of a literature review about the design and construction of an AUV, existing design, and properties of materials. These reviews will be the guideline for this research to give the overview of the design of hydrodynamic body structure of autonomous underwater vehicle application.

2.1 Design and Construction of an AUV

Designing the body structure of an AUV need guideline that can be references to get a better understanding of its parts such as the hull, thrusters positioning, and body frame is important. These parts are quintessential and play the most important roles in building the body structure of an AUV.

2.1.1 Main Hull

The hull design should be easily removed and easily accessible for maintenances. The hull must have modularity for future changes of the components (M. S. M. Aras et. al., 2009). An AUV must provide a pressure hull to house its components in a dry, watertight environment. The hull must allow components to be easily accessible and maintainable, as well as allowing for modularity in case of future changes or additions. Spherical hulls offer the best structural integrity; however, the shape inhibits the efficient use of the space available as most components and systems are rectangular. Cylindrical hulls provide the best alternative, comprising high structural integrity and shape conducive to the housing of electronic components (L. A. Gonzalez, 2004).

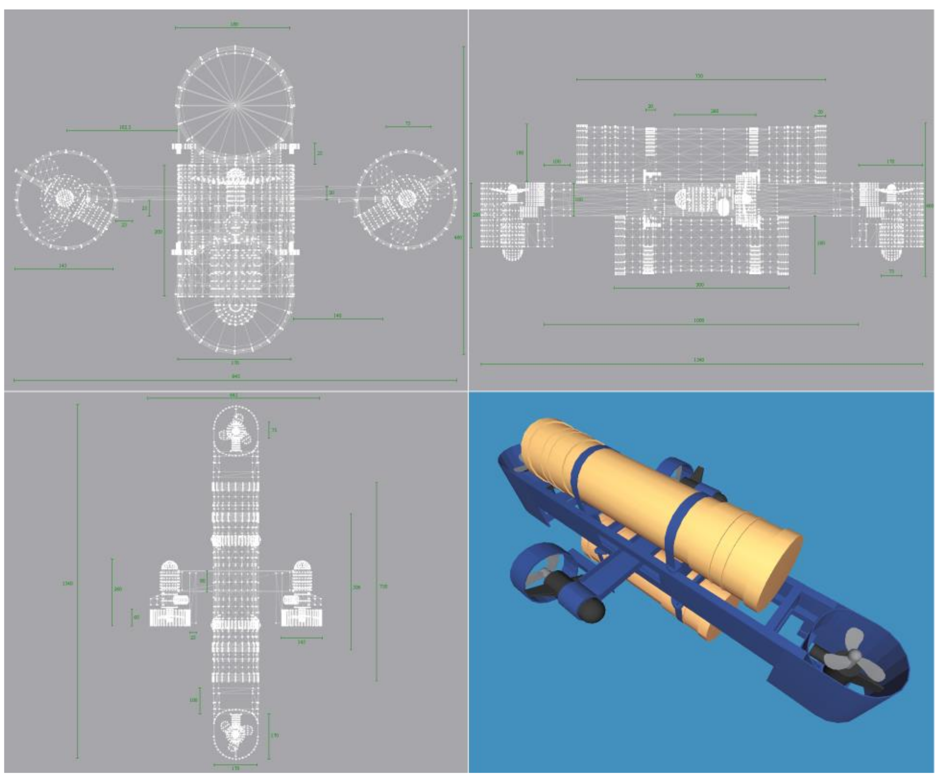

Figure 2.1: Mako AUV (University of Western Australia) *(Source: L. A. Gonzalez, 2004)*

Figure 2.2: Orca-IV AUV (MIT) *(Source: L. A. Gonzalez, 2004)*

Mako AUV from Figure 2.1 composed of two cylindrical hulls which the upper contain the main components and the lower hull contain the batteries. Both of this cylindrical container and the body frame help shape the hull itself to be more hydrodynamic. This kind of design also is shown in Orca IV AUV from MIT in Figure 2.2 but this AUV show more cylindrical shaped hull with more exposed components on the side (L. A. Gonzalez, 2004).

The main hull also must be in the middle because it has the most weight containing all the controllers and board computers components. Putting it in the central position allow the center of gravity of the vehicle to be at the most perfect position for good hydrostatic stability and maneuverability. Putting it in the middle also give advantages of ease on handling the electrical connections with the other components such as the thrusters and the sensors. From Figure 2.4, it can be clearly seen that the main hull is in the middle with other components at its surrounding which make it easy for connection as it is a compact AUV (J. Gelli et. al., 2018).