DEVELOPMENT OF MODULAR HULL OF A SUBMERSIBLE VEHICLE FOR ENGINEERING SERVICES

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**A thesis submitted
in fulfillment of the requirements for the degree of Bachelor of Mechanical Engineering with Honours**

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MARCH 2018

DECLARATION

I Ibrahim Bin Mohamad declares that this project report entitled “Development of modular hull of a submersible vehicle for engineering services”, under the guidance of Dr. Shamsul Anuar Bin Shamsudin, is my original work except references material.

Signature : ______________________________

Name : Ibrahim Bin Mohamad

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.

Signature	:	______________________
Supervisor	:	Dr. Shamsul Anuar Bin Shamsudin
Date	:	______________________

DEDICATION

I dedicated this study to my beloved parent Mohamad Bin Rasid and Normah Binti Saad, who always give their support and motivation to finish my study until the end. I also want to thank my siblings who never fail to always be by my side cheering and supporting me to work harder to complete my study. Also, a token of appreciation to my friends who were always helping me throughout the process. All their efforts, guidance and support will always be appreciated especially to Dr. Shamsul the person who always guide me towards completing my work. Again, a very special thanks to everyone, knowing or without knowing who contributed towards helping me finishing this work and supported me till the end.

ABSTRACT

As the need and applications of Autonomous Underwater Vehicles (AUVs) increase day by day, the research on AUVs become a popular and important topic nowadays. A respectable number of publications are available periodically. Among the existing candidate vehicles for autonomous underwater application are the Bluefin-21 from Bluefin robotics. It is a torpedo-shaped multipurpose AUV capable of conducting oceanic military, scientific and search and rescue operations. Utilizing a modular design powered by interchangeable Lithium-polymer batteries, it can operate on the Sea floor for up to sixteen hours at a time. In 2014, the Bluefin-21 was deployed to conduct undersea sensor sweeps during the international effort to locate the wreckage of Malaysia Airlines Flight 370. Next is the Bluefin SandShark Micro-AUV. This is an autonomous UUV weighing less than 15 pounds that was developed by General Dynamics Mission Systems subsidiary also from Bluefin Robotics. Its functions include intelligence missions, small-scale survey missions recovering data, communications relays, conducting training, or functioning as a decoy for the United States Navy unfortunately till now a review report on current status of the works done on AUVs is hard to find in literature. This paper presents a comprehensive survey on recent works done on AUVs and its applications in real life. Scientific researches on AUVs and the great achievements in India and abroad are presented. A brief history of chronological development of technologies of AUVs is established. A note on possible directions and works may be done in future is also mentioned. This paper is intended to serve as an immense reference for the future researchers working in the field of AUV.

ABSTRAK

Memandangkan keperluan dan penggunaan Kenderaan Bawah Air Autonomi (AUVs) meningkat setiap hari, penyelidikan mengenai AUV menjadi topik yang popular dan penting pada masa kini. Bilangan penerbitan yang dihormati tersedia secara berkala. Antara kenderaan kandidat sedia ada untuk aplikasi bawah laut autonomi ialah Bluefin-21 dari robotfin Bluefin. Ia adalah AUV serba guna yang berbentuk torpedo yang mampu menjalankan operasi ketenteraan, saintifik dan mencari dan menyelamat lautan. Dengan menggunakan reka bentuk modular yang dikuasakan oleh bateri lithium-polimer yang boleh ditukar ganti, ia boleh beroperasi di dasar laut sehingga enam belas jam pada satu masa. Pada tahun 2014, Bluefin-21 telah digunakan untuk melakukan kebolehtelapan sensor bawah laut semasa usaha antarabangsa untuk mencari bangkai Penerbangan Malaysia Airlines 370. Seterusnya ialah Bluefin SandShark Micro-AUV. Ini adalah kenderaan yang beratnya kurang daripada 15 paun yang dibangunkan oleh anak syarikat General Dynamics Mission Systems juga dari Bluefin Robotics. Fungsi-fungsinya termasuk misi perisikan, misi survei kecil-kecilan yang memulihkan data, relay komunikasi, menjalankan latihan, atau berfungsi sebagai umpan untuk Tentera Laut Amerika Syarikat Malangnya sehingga kini laporan kajian mengenai status semasa kerja-kerja yang dilakukan di AUV sukar ditemui dalam kesusasteraan . Makalah ini membentangkan tinjauan komprehensif mengenai kerja-kerja terkini yang dilakukan pada AUV dan aplikasinya dalam kehidupan sebenar. Penyelidikan saintifik mengenai AUV dan pencapaian hebat di India dan luar negara telah dibentangkan. Sejarah ringkas perkembangan kronologi teknologi AUVs ditubuhkan. Nota mengenai arah dan kerja yang mungkin dilakukan pada masa akan datang juga disebutkan. Inilah tesis yang dimaksudkan untuk menjadi rujukan besar bagi penyelidik masa depan yang bekerja di bidang AUV.

ACKNOWLEDGEMENTS

First, I would like to take this opportunity to express my gratitude to my supervisor Dr. Shamsul Anuar Bin Shamsudin from the Faculty of Mechanical Engineering Universiti Teknikal Malaysia Melaka (UTeM) for being able to supervise, give support and encouragement towards the completion of this final year project. I also want to thank the staff of Faculty of Mechanical Engineering laboratory who always support and give good cooperation to finish this project smoothly. Not forgotten to express my appreciation to technician of Faculty of Mechanical Engineering who always assist and sharing the knowledge to used equipment and tools. Finally, I want to express special thanks to my family especially to my parents, to my beloved siblings, and to my colleague for their moral support in completing this degree.

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LIST OF ABBREVIATION

AUV Autonomous Underwater Vehicle

FEA Finite Element Analysis

CFD Computational Fluid Dynamic

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Over the past few decades AUVs have matured from research and experimental vessels to commercially available systems. Commercially available AUVs are expensive and complex. Most AUVs are single hull systems with centralized electronics. With advancement in technology, newer sensors have been developed for a variety of operations which can be integrated in AUV systems.

With single hull AUVs it is not easy to integrate newer and upgraded sensors without making significant changes to the mechanical and electrical systems. This has given rise to interest in modular designs for AUVs. Modular AUV structures in hardware as well as software have significant advantages. Modules for different sensors can be made and interchanged to `configure the same basic AUV for different missions.

With a team of such modular AUVs, configurable sections can allow the user to setup the team for different group missions as per requirements. In case of failures, individual sections can be easily replaced and debugged, which significantly reduces time.

To model the design process of pressure hull, a dedicated system based on VISUAL BASIC was developed. During the design process, the principle "simple, convenient and smart" is an essential step to follow. The patterns for calculating and checking were built by computer programming language. Using this system, the designer will get the results quickly and correctly. Figures 1.1 and 1.2 are the examples of an underwater vehicle and how it is used for engineering work

Figure 1 Underwater Vehicle By Tesla Offshore

Figure 2 Use of AUV for engineering services

1.2 PROBLEM STATEMENT

The highly cost and risky situation faced by the people that are involve in submersible and autonomous underwater robots encounters one general issue which is to come up with an effective and efficient solution for underwater missions. The intention of reducing the cost and risks produces opportunity for the communities practicing unmanned marine vehicles. This makes it possible to come up with a solution on how unmanned marine vehicles interact with users and other support systems, and how much work that they can manage on their own or working with other unmanned marine vehicle. The challenge is to develop a body that can withstand high pressure deep underwater without crushing the body and of course cause leakage that could gravely affect the robot in a whole. The challenge also took account the hydrodynamic features of the body. Therefore, a new and lower cost design requires a degree of certainty regarding all the challenges.

1.3 OBJECTIVES

The objectives of this project are as follows:

1. To design and develop a modular hull of a submersible vehicle for engineering services.
2. To apply the knowledge of an engineering software CATIA by designing the modular hull of a submersible vehicle.
3. To provide a complete analysis on the development of the modular hull and to propose to engineering solutions.

1.4 SCOPE OF PROJECT

The scopes of this project are:

1. To conduct the literature review.
2. The process covers the full design in CATIA software which will be presented in this report.
3. The conduct drawing, strength testing analysis, and the hydrodynamics of the AUV parts using Ansys software.
4. Developing the hardware for the modular hull and doing a test run simulation.
5. Report writing.

CHAPTER 2

LITERITURE REVIEW

2.1 DESIGN AND CONSTRUCTION OF AN UNDERWATER VEHICLE

Autonomous underwater vehicle (AUV) has become a widely known topic used for industrial applications, military and of course to explore the ocean. Regarding that, AUVs has become one of the main option for underwater search or survey operations as they cost less than manned vehicles. Previous plans on developing an AUV focuses more on functional designs instead of identifying optimum designs. Through time, as the importance to minimizing the use of recourses (e.g. fuel, building cost, time for design etc.) becomes very clear, the approach of optimization becomes increasingly popular. (Khairul Alam, Tapabrata Ray and Sreenatha G. Anavattiet. al, 2013).

2.2 EXISTING DESIGN

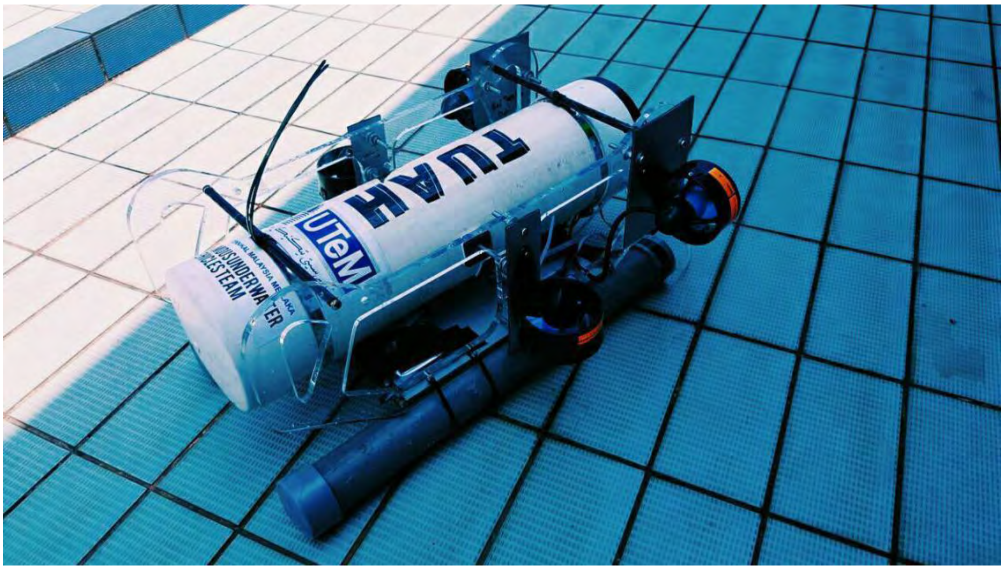

Figure 3 Tuah Autonomous Underwater Vehicle

The Figure 1.3 above shows the design of autonomous underwater vehicle named TUAH which is design by the students of University Technical Malaysia Melaka (UTeM). This AUV is used in the international robotics competition SAUV which stands for Singapore Autonomous Underwater Vehicle in the year 2017. Among all the contestant. The AUV Tuah turns out to be the 3rd fastest vehicle during the qualification rounds. The design of the AUV in this project is roughly based on the design of TUAH's but with an improvement being made.

2.3 STABILITY ANALYSIS

The design of the body of an AUV needs to be stable underwater. The body needs to balance and must ensure that it does not disturb the electronic parts. Among all the electronic parts, the censor that is used to balance the AUV is called IMU. Its function is to balance the AUV, therefore the position of the AUV must be stable for the IMU to work efficiently. To make sure the quality of the data collected, underwater inspection mission requires an AUV with high stability, especially in roll and pitch direction. However, AUV with adopt torpedo-shaped body, has limited passive restoring moment in roll and pitch direction (Y.S Song et al., 2015).

2.4 HYDRODYNAMIC FLOW

The body of an autonomous underwater vehicle should be hydrodynamic. This means the drag force should not be high. This is to ensure the smoothness of the movement of the vehicle. Among the ways of making sure that the body is hydrodynamic is that the position of the thrusters or steerers needs to be placed at a suitable position. (Lingbo Geng, Zhi Qiang Hu and Yang Lin et al., 2017)

2.5 THE DEVELOPMENT OF NEW AUTONOMOUS UNDERWATER VEHICLE

Among the development of new autonomous underwater vehicle focuses on an AUV that can travel for a long distance. It is called the next generation of AUV. The process of developing defines vehicle specification for the AUV to travel far distance. This includes the configurator, censor and water testing. The test to analyze the body includes the fluid property test and maneuvering control properties to examine the body before further developing it. (Ikuo Yamamoto et al., 2015).

2.6 PROPERTIES OF MATERIAL

The most crucial decision that needs to be made is the selection of material before designing the whole body. The overall design is based on the design of Blue ROV from blue robotics. Blue ROV is an AUV that is commercially available worldwide. The differences lie on the type of material used to build the frame, and its efficiency. The material that is chosen for this study is the Acrylic. Therefore, the properties of the acrylic are crucial information that needs to be obtain, before proceeding with the design. The properties that are considered for this project are physical properties, mechanical properties, electrical properties and thermal properties. The material chosen for this design is acrylic.

The information of the properties of acrylic is as shown in table below.

Table 1 Physical properties of Acrylic

Physical Properties	Metric
Density	1.18 - 1.19 g/cc
Water Absorption	0.130 - 0.800 %
Water Absorption at Saturation	0.650 - 2.60 %
Moisture Expansion	0.500 %
Moisture Vapor Transmission	55.0 cc-mm/m²-24hr-atm

Table 2 Mechanical Properties of Acrylic

Mechanical Properties	Metric
Hardness, Barcol	49.0 - 50.0
Hardness, Rockwell M	94.0 - 105
Ball Indentation Hardness	175 MPa
Tensile Strength, Ultimate	62.0 - 83.0 MPa
Tensile Strength, Yield	64.8 - 83.4 MPa
Elongation at Break	3.00 - 6.40 %
Modulus of Elasticity	2.76 - 3.30 GPa
Flexural Yield Strength	98.0 - 125 MPa
Flexural Modulus	2.96 - 3.30 GPa
Compressive Yield Strength	110 - 124 MPa
Compressive Modulus	2.76 - 3.03 GPa
Poissons Ratio	0.370
Shear Modulus	1.70 GPa
Shear Strength	25.5 - 62.1 MPa
Izod Impact, Notched	0.160 - 0.220 J/cm
Izod Impact, Notched (ISO)	1.60 kJ/m²
Charpy Impact Unnotched	1.20 - 2.17 J/cm²
Coefficient of Friction	0.450 - 0.800

Table 3 Electrical Properties of Acrylic

Electrical Properties	Metric
Electrical Resistivity	1.00e+15 - 1.60e+16 ohm-cm
Surface Resistance	5.00e+13 - 1.90e+15 ohm
Dielectric Constant	2.70 - 4.00
Dielectric Strength	17.0 - 30.0 kV/mm
Dissipation Factor	0.0200 - 0.0600
Comparative Tracking Index	600 V

Table 4 Thermal Properties of Acrylic

Thermal Properties	Metric
CTE, linear	61.0 - 198 µm/m-°C
Specific Heat Capacity	1.46 - 2.16 J/g-°C
Thermal Conductivity	0.187 - 0.209 W/m-K
Maximum Service Temperature, Air	70.0 - 200 °C
Deflection Temperature at 0.46 MPa (66 psi)	110 - 115 °C
Deflection Temperature at 1.8 MPa (264 psi)	86.0 - 115 °C
Vicat Softening Point	105 - 118 °C
Minimum Service Temperature, Air	-40.0 - -32.2 °C
Flammability, UL94	HB
Flame Spread	5.84 - 36.0 mm/min
Flash Point	425 - 488 °C
Smoke Density	5.00 - 65.0

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION OF METHODOLOGY

This chapter describes the methodology used in this project to design and analyses the body of autonomous underwater vehicle. The flow chart shows the process stage. This project starts by studying the best way to obtain the best design preparation and to compare it with the existing design. By obtaining the best design, it can be a good result in experiment testing and to prove the efficiency compared to an existing design.

3.2 GENERAL PROCESS

The overall process of the project can be visualized by referring to the flow chart in Figure 4. The first stage of process focuses on information study and gathering related data s from the journal, book, newspaper, websites and relevant sources. From the information data, the suitable material and the process method that can be used to developed new submersible hull can be determined and the type of impact test can be used for testing. References based on journals, articles, books and any related material regarding this project will be reviewed.