UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF BODY STRUCTURE OF SMALL SCALE ROV FOR EDUCATIONAL PURPOSES

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BACHELOR OF MECHANICAL ENGINEERING TECHNOLOGY (MAINTENANCE TECHNOLOGY) WITH HONOURS

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A thesis submitted
in fulfillment of the requirements for the degree of
Bachelor of Mechanical Engineering Technology (Maintenace Technology) with Honours

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2022

DECLARATION

I declare that this thesis entitled "Development of Body Structure of Small Scale ROV for Educational Purposes" 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.

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APPROVAL

I hereby declare that I have checked this thesis and, in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor of Mechanical Engineering Technology (Maintenance Technology) with Honours.

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Date	:	18 JAN 2022

DEDICATION

My work is dedicated to my family and other friends. Recognize that any difficult task needs self-effort as well as assistance and direction from elders and friends. Also, a particular thank you to my dear parents for their words of support and prayers throughout the day and night. I also dedicate my effort to my supervisor, who has helped me to do the genuine task by myself. I can handle the task, even the competitor that is extremely difficult to accomplish, because of this support. I was able to achieve such achievement thanks to their encouragement and guidance. Thank you for all of your help and recommendations.

ABSTRACT

The evolution of technology is going to accelerate the development of ROV technology in the educational sector, but there are numerous obstacles in the process of developing all ROVs, particularly in the manufacturing of its frames. Thus, this paper describes the development of the body structure of a small size ROV for educational purposes, with chapter-by-chapter details. The major objectives of this paper were to develop a small size ROV body structure, fabricate a small-scale ROV suitable for educational purposes, and finally develop a ROV’s body frame that able to withstand the underwater pressure. The ROV's body frame is created using engineering design methodologies such as House of Quality (HOQ), Morphological chart, and Pugh method. The final frame of the small scale ROV was developed and tested. The final frame dimensions of the small-scale ROV were 300 mm x 310 mm x 200 mm, with a thickness of 20 mm. Additionally, the box design frame of the small-scale ROV was chosen due to its adaptability and engineering capabilities, which allow it to dive successfully underwater. The nylon FS 3300 PA was chosen for the overall materials of the frame, as well as its capacity to resist underwater pressure, simplicity of fabrication, and other engineering advantages. The SLS machine was used to create and fabricate the body frame, thruster base, rear rod, and grabber holder, as well as the printing procedures, all of which were measured according to industry standards. The result demonstrates the design and manufacture of a body frame for a small size ROV for educational purposes was able to develop and fabricate, using a box shape and nylon FS 3300 PA as the material. The capacity of the body frame to withstand the underwater pressure was analyzed by using Autodesk Inventor. To prevent fracture difficulties, the ideal depth for the ROV to dive was within or around one meter. The results also suggest that the ROV's body frame will be subjected to the maximum stress pressure, causing the body frame to bend. The commercialization potential is strong owing to the applicability of the small-scale ROV utilised to assist the educational sector in exploratory activities and expose students to the technology of SLS 3D Printing.

ABSTRAK

Evolusi teknologi akan mempercepatkan pembangunan teknologi ROV dalam sektor pendidikan, tetapi terdapat banyak halangan dalam proses membangunkan semua ROV, terutamanya dalam pembuatan bingkainya. Oleh itu, kertas kerja ini menerangkan pembangunan struktur badan ROV bersaiz kecil untuk tujuan pendidikan, dengan perincian bab demi bab. Objektif utama kertas ini adalah untuk membangunkan struktur badan ROV bersaiz kecil, menghasilkan ROV berskala kecil yang sesuai untuk tujuan pendidikan, dan akhirnya membangunkan rangka badan ROV yang mampu menahan tekanan dalam air. Rangka badan ROV dicipta menggunakan metodologi reka bentuk kejuruteraan seperti House of Quality (HOQ), carta Morfologi dan kaedah Pugh. Bingkai akhir ROV skala kecil telah dibangunkan dan diuji. Dimensi bingkai akhir ROV berskala kecil ialah 300 mm x 310 mm x 200 mm, dengan ketebalan 20 mm. Selain itu, bingkai reka bentuk kotak ROV berskala kecil telah dipilih kerana kebolehsuaian dan keupayaan kejuruteraannya, yang membolehkannya menyelam dengan jayanya di bawah air. Nilon FS 3300 PA dipilih untuk bahan keseluruhan bingkai, serta kapasitinya untuk menahan tekanan bawah air, kesederhanaan fabrikasi dan kelebihan kejuruteraan yang lain. Mesin SLS telah digunakan untuk mencipta dan mengarang rangka badan, tapak pendorong, rod belakang dan pemegang pemegang, serta prosedur pencetakan, yang kesemuanya diukur mengikut piawaian industri. Hasilnya menunjukkan reka bentuk dan pembuatan rangka badan untuk ROV bersaiz kecil untuk tujuan pendidikan dapat membangun dan membuat, menggunakan bentuk kotak dan nilon FS 3300 PA sebagai bahan. Kapasiti rangka badan untuk menahan tekanan bawah air dianalisis dengan menggunakan Autodesk Inventor. Untuk mengelakkan kesukaran patah, kedalaman ideal untuk ROV menyelam adalah dalam atau sekitar satu meter. Keputusan juga mencadangkan bahawa rangka badan ROV akan dikenakan tekanan tekanan maksimum, menyebabkan rangka badan membongkok. Potensi pengkomersilan adalah kukuh berikutan kebolehgunaan ROV berskala kecil yang digunakan untuk membantu sektor pendidikan dalam aktiviti penerokaan dan mendedahkan pelajar kepada teknologi Pencetakan 3D SLS.

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TABLE OF CONTENTS

	PAGE
DECLARATION	
APPROVAL	
DEDICATION	
ABSTRACT	**i**
ABSTRAK	**ii**
ACKNOWLEDGEMENTS	**iii**
TABLE OF CONTENTS	**iv**
LIST OF TABLES	**vi**
LIST OF FIGURES	**vii**
LIST OF SYMBOLS AND ABBREVIATIONS	**ix**
LIST OF APPENDICES	**x**
CHAPTER 1 INTRODUCTION	**1**
1.1 Background of Study	1
1.2 Problem Statement	2
1.3 Research Objective	3
1.4 Scope of Research	4
CHAPTER 2 LITERATURE REVIEW	**5**
2.1 Introduction of Literature Review	5
2.2 The Classification of the ROV	5
2.3 Basic Component of ROV	7
2.3.1 Frame or Body Structure	8
2.3.2 Lamps	10
2.3.3 Thruster	11
2.3.4 Power Module	12
2.3.5 System of Propulsion	14
2.3.6 Gripper or Manipulator	15
2.3.7 Ballast Weight	16
2.3.8 Camera	17
2.4 Design Concept	19
2.4.1 Design of ROV's Body Frame	21
2.5 Buoyant Force	23
2.6 Hydrodynamics	27
2.7 Material Selection	30

2.7.1 Nylon for SLS 32
2.8 Bolt and Screw Factor of Safety 35
2.9 Bolt and Screw Analysis 38
2.10 Application ROV in Education 40
2.11 Manufacturing Process 41

CHAPTER 3 METHODOLOGY 44
3.1 Introduction of Methodology 44
3.2 Flow Chart of Methodology 44
3.2.1 Overview of Methodology 46
3.2.2 Frame Design Small-Scale ROV Using (HOQ) 47
3.2.3 Morphological Chart of Overall Design 47
3.2.4 Concept of ROV Using Pugh Method 48
3.3 Proposed Design 48
3.4 Raw Material 50
3.4.1 Nylon FS 3300 PA 50
3.5 Fabrication Process of Selected ROV's Frame Design 51
3.5.1 Designing Process 52
3.5.2 Printing Process 53
3.5.3 Selective Laser Sintering (SLS) Machine Parameter 55
3.6 Testing and Analysis 56

CHAPTER 4 RESULTS AND DISCUSSION 58
4.1 House of Quality fro ROV's Body Frame 58
4.2 Morphological Chart of ROV's Body Frame 61
4.2.1 Conceptual Design 62
4.3 Evaluate Concept Using Pugh Method 63
4.4 Final Design for ROV's Body Frame 65
4.5 Stress Analysis Using Inventor 2020 67
4.5.1 Body Frame Stress Analysis 68

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS 72
5.1 Conclusion 72
5.2 Recommendations 73
5.3 Project Potential 74

REFERENCES 75

APPENDICES 79

LIST OF TABLES

TABLE	TITLE	PAGE
Table 2.1 Common Types of ROV		21
Table 3.1 Nylon FS 3300 PA Properties based on Farsoon Technologies website		51
Table 3.2 Fixed parameters in SLS		56
Table 4.1 House of Quality for the ROV's body frame		60
Table 4.2 Morphological Chart of ROV's Body Frame		61
Table 4.3 Conceptual Design of ROV's Body Frame		62
Table 4.4 Final score for the weight of the Pugh method		64
Table 4.5 The Calculation of Applied Pressure for Analysis		68

LIST OF FIGURES

FIGURE	TITLE	PAGE
Figure 1.1 Previous Design of ROV		3
Figure 2.1 Class of Subea Vehicle		7
Figure 2.2 Basic Component of Inspecton ROV		8
Figure 2.3 Sample of Mirco ROV Frame		10
Figure 2.4 The ROV’s Lamp Used for Underwater Exploration		11
Figure 2.5 3 Blades Thruster		12
Figure 2.6 Power Source of ROV		13
Figure 2.7 Propulsion System of ROV		15
Figure 2.8 Gripper That Applied on the ROV		16
Figure 2.9 The Ballast Weight of ROV		17
Figure 2.10 Example of ROV’s Camera		18
Figure 2.11 Archimedes Principle		24
Figure 2.12 Buoyant Force Formula		25
Figure 2.13 Coordinate System		27
Figure 2.14 The application of Industrial ROV in Seawater		30
Figure 2.15 Nylon 6 Properties		33
Figure 2.16 Nylon 12 Properties		34
Figure 2.17 Characteristic of Nylon		35
Figure 2.18 Safety Factor Formula		36
Figure 2.19 Type of Bolt and Nut Used in Subsea		37
Figure 2.20 Ideal Safety Factor		38

Figure 2.21 Analysis of Bolt Using Inventor 2020 40
Figure 2.22 Falcon (ROV) for Education Purpose 41
Figure 2.23 Example of Modern 3D Printer Machine 43
Figure 3.1 Process Flow Chart of Frame Design Small-Scale ROV 45
Figure 3.2 Orthographic Projection of ROV’s Body Frame 49
Figure 3.3 Exploded View (ROV's Body Frame) 50
Figure 3.4 Working Flow of 3D Printing 52
Figure 3.5 Estimation Production Time 54
Figure 3.6 Cleaning Process Using Powder Purify Station 55
Figure 3.7 Water Tanks for Testing 57
Figure 4.1 Final Design Seelction 65
Figure 4.2 Design of ROV’s Frame Design 66
Figure 4.3 Formula of Hydrostatic Pressure 67
Figure 4.4 Example of Von Misies Stress Analysis Using Inventor 69
Figure 4.5 Graph of Stress Analysis 69
Figure 4.6 Actual Testting for ROV 71

LIST OF SYMBOLS AND ABBREVIATIONS

mm	-	Milimeter
m	-	Meter
Pa	-	Pascal
MPa	-	Mega Pascal
W	-	Watt
°C	-	Celcius
s	-	Second
cm	-	Centimeter

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
APPENDIX A	House of Quality for frame of small-scale ROV.	79
APPENDIX B	Characteristic of frame of the small-scale ROV for 3 options	80
APPENDIX C	Evaluate Concept Using Pugh Method	80
APPENDIX D	Detail Dimension of Body Frame's Part	81
APPENDIX E	Analysis Using Inventor	82
APPENDIX F	Cost Analysis	83
APPENDIX G	Actual Product	84

CHAPTER 1

INTRODUCTION

1.1 Background of Study

A Remotely Operated Vehicle (ROV) is identical to an Autonomous Underwater Vehicle (AUV) since both are underwater vehicles programmed to deliver specific tasks. The ROV has mostly been used for underwater restoration, maintenance, and operations as in offshore sectors, marine biology and sustainable sources, naval defense, maritime exploration, and rescue (research-based purpose). The ROV is designed to do risky or hazardous operations and utilizes systems for predicting, classification, and diagnostics. Several manufacturers, on the other hand, are concentrating on underwater surveillance and have established ongoing activities with specific objectives.

Despite this, substantial progress has been made in several aspects of ROV utilisation and improvement. Due to the wide range of fortes that become a crucial component in obtaining ideal applicability, it was an appealing research topic. In the inspection sector, the precision detection of underwater applications has become a prominent concern. Efforts have been made to identify a GPS-based frame where the representation of the application framework for this scenario was accomplished by a quantifiable analysis, taking into consideration varying quantities of data. Also, for underwater companies, a one-of-a-kind programmable occurrence acoustic indicator with sound example recognition has been created. *(García-Valdovinos et al., 2019)*

Since 1992, the ROV has been utilised in educational sector to integrate advanced research knowledge, instrumentation, and approaches to organisations and the use of the maritime ecosystem, as well as to raise the number of competent professionals working in "important advanced technology sectors." ROVs have been used in a variety of educational programme. ROV-based teaching programme and tasks might be utilised to stimulate people's interest in innovation and design and improve their comprehension of the principles. Yet, no research exists to determine the impact of a ROV movement or programme on improving apprentice attention, perhaps the appearance of innovation. *(Bates et al., 2016)*

1.2 Problem Statement

The issues in developing the body frame, as well as the expansion of the area of the ROV for educational purposes, were carried out by the last manufacturer. The proposed body frame is inappropriate for educational purposes as several critical parameters do not comply. The past manufacturer's main consideration while designing the body frame for the educational proposal was the durability of the body frame withstand the underwater pressure. The ability to withstand the underwater pressure is crucial in the development of the ROV as it is the other element that enables the ROV to work successfully. Likewise, the past manufacturer is dealing with the issue of assuring the ROV's buoyancy. The buoyancy of the ROV assist in its reliability when performing the assessment underwater, and it may move as far as the apprentice desires without failure. The ROV is unable to perform optimally since the design used is not acceptable for educational purposes.

Figure 1.1 Previous Design of ROV

1.3 Research Objective

The purpose of the project is to develop a small-scale ROV body structure suited for high school students to operate. To achieve the goal, several objectives should be managed to be met:

a) To design the concept of small-scale body structure of the ROV that suitable for educationl purpose.

b) To fabricate the small-scale of ROV that suitable for educational purpose.

c) To develop the ROV’s body frame able to withstand underwater pressure.

1.4 Scope of Research

The scope of this study:

- Design a small-scale body structure with dimension of 300 mm x 310 mm x 200 mm in size, with a thickness of 20 mm.
- Fabricate the body frame of ROV using the 3D Printing Machine (SLS Machine).
- The develop the ROV’s body frame able to withstand the underwater pressure within 1 meter (0.25 m).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of Literature Review

The literature review chapter will compile project-related information from journals, articles, books, and internet portals. The purpose of a literature review is to provide an overview of the sources that were explored while researching a particular topic and to explain how the research concept fits within a wide field of study. It provides an overview of current knowledge, identifying relevant concepts, approaches, and research requirements.

2.2 The Classification of the ROV

The development of robotics, a hybrid technology with mostly mechanical and electrical applications, has allowed people to complete challenging operations and specialization on shore, at sea, in the air, and underwater in today's advanced technological improvement. Nonetheless, as the exploration of the ocean below progresses, we can see that underwater technology and robots are becoming increasingly attractive to see.

An unmanned underwater vehicle (UUV), according to Chengxi Wu (2017), is controlled by a submarine or surface vessel that functions as the operating system for the vehicle. It is classified into two categories: remotely controlled underwater vehicles (ROVs) and autonomous underwater vehicles (AUVs). Among the most significant high-tech developments in the fields of marine exploration, development and exploitation is the underwater robotics system. Underwater robots are adaptable, fluid, and dynamic, and they can operate at a depth of up to 100 metres under the sea. It is also capable of operating in a wide range of environments and has a high level of durability. The ROV is also capable of supporting large quantities of power as well as complicated operating machinery. *(Wu, 2017)*

Work-class ROVs are the employees of the marine engineering industry, and they perform a variety of tasks. Large portions of its use are accounted for by the offshore oil and gas industries. Their primary mode of transportation is usually by electricity, with some including hydraulic subsystems for manipulator control. In addition to drilling, cleaning and hot stabbing, they are capable of operating at a far greater depth (up to 3000 m) than inspection-class vehicles. For many ROV applications, large vehicles are ineffective or impracticable, and an inspection classification system may be used instead, depending on the circumstances.

In terms of inspection capabilities, ROVs are divided into three categories: medium, portable, and micro. In certain cases, just manpower is required for the deployment and recovery of micro or portable inspection ROVs. It is possible for these vehicles to be fitted with miniature manipulators that are capable of grasping light objects. This ROV classification is only applicable to depths of less than 300 metres in the ocean. Due to its small size and weight, the thrust to weight ratio may be relatively high, despite its small size and weight. Even though their stability is often low when compared to open-frame medium inspection ROVs, this is due to the way they are constructed. *(Capocci et al., 2017)*

The advancement of technology has made it possible to build a broad range of ROV models, including a number of low-cost alternatives that allow researchers to get more access to deep-water environments. Due to the fact that the connecting line no longer supplies energy to the ROV system, the tethering thickness was lowered, which improved the agility of the ROV significantly. As low-cost components and assembly instructions for remotely operated vehicles (ROVs) become more widely available, researchers and the general public will have more access to these devices.

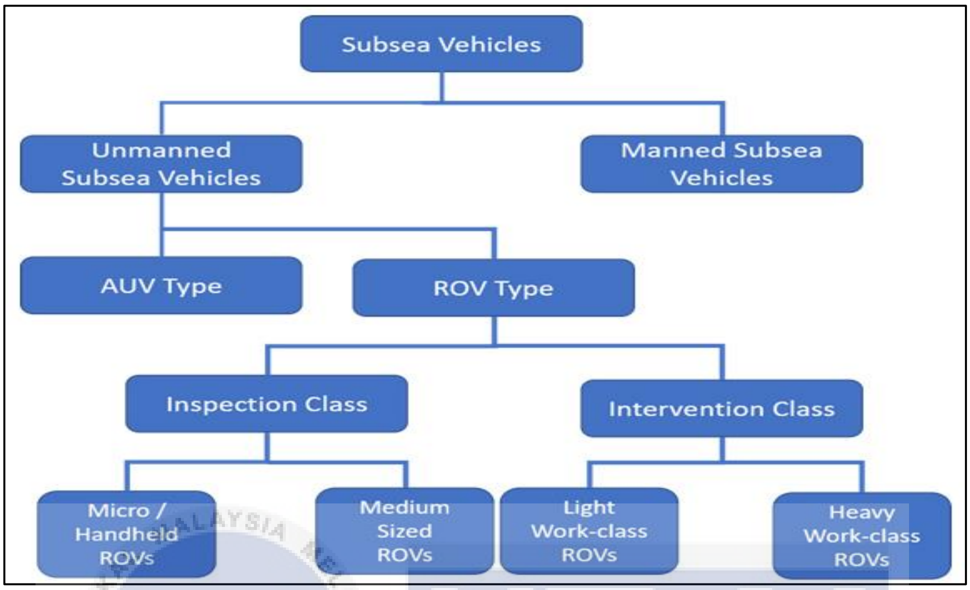

Figure 2.1 Class of Subea Vehicle

2.3 Basic Component of ROV

Remote Operated vehicles (ROVs) are theoretically the simplest type of robot to manufacture. The capacity of the ROV to navigate under its own power was a distinguishing characteristic, and it allowed the ROV to perform to its maximum capabilities. Additionally, the ROV is equipped with navigational skills, which enable it to perform a wide range of activities underwater. Because of the adaptability of the ROV system, it is possible to complete any operation, no matter how difficult or complex this might be. *(Ayob et al., 2017)* As a consequence, two components of ROV construction should be addressed on a broad scale: practicality and cost-effective design, both of which are meant to assist potential customers in completing their responsibilities.

Aside from that, the ROV has its own depth limitation for diving in the sea, which may compromise the diver's ability to complete the job successfully. When the ROV dives below to execute any activity, the components mounted on the ROV must be capable of balancing the ROV at all times so that it can complete the operation. Given how much the weight of each attached component influenced the manoeuvrability of the ROV, the weight of each attached component was regarded to be one of the most important factors to take into account. To minimise damage to the ROV's water-resistant components, it is essential that they are properly sealed before use. This is especially the case for the electronic components, which are particularly sensitive to the presence of water. For the ROV to remain stable at the prescribed depth, it is necessary that all of the components used fulfil the required depth and safety criteria. As shown in Figure 2.2, numerous important aspects of the ROV are commonly used.

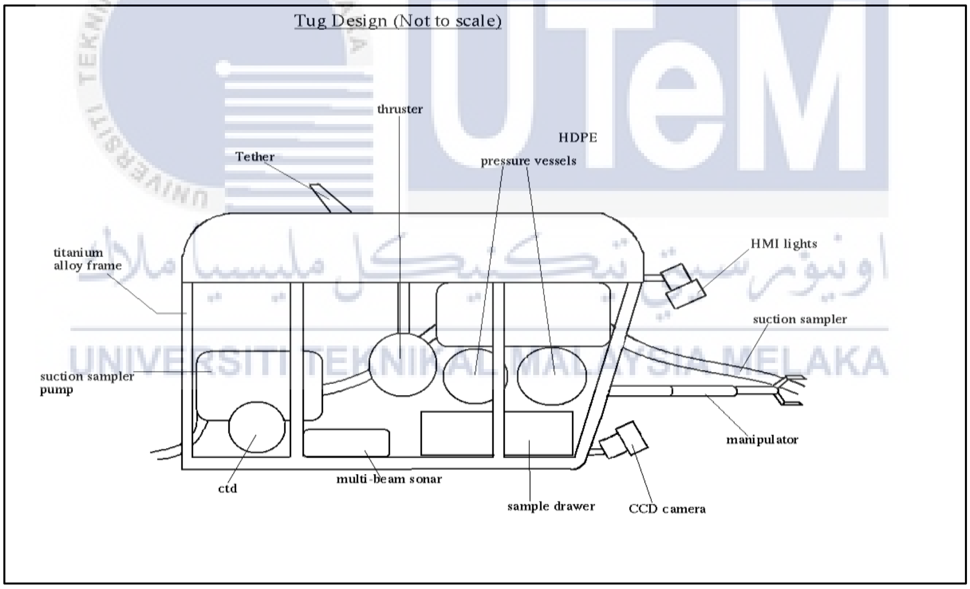

Figure 2.2 Basic Component of Inspecton ROV

2.3.1 Frame or Body Structure

In the course of operations, the ROV's frame is being used to install equipment, and it also functions as a support and protection framework. Utilising open frames, which allowed for clear water flows to the thrusters, the majority of ROV manufacturers improve