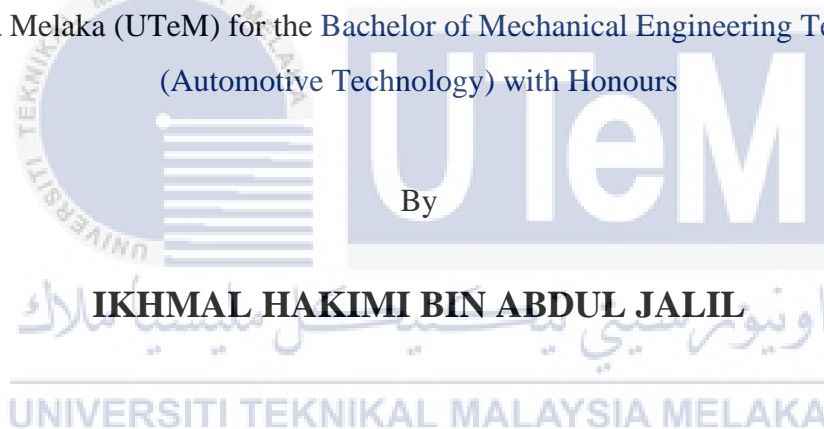




UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DEVELOPMENT OF GRABBER STRUCTURE OF
SMALL SCALE ROV FOR EDUCATION PURPOSES**

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours



supervised by

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**FACULTY OF MECHANICAL AND MANUFACTURING
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2021/2022 Semester 2




DECLARATION

I hereby, declared this report titled DEVELOPMENT OF GRABBER STRUCTURE OF SMALL SCALE ROV FOR EDUCATION PURPOSES is the results of my research except as cited in references.

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APPROVAL

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ABSTRAK

Pelbagai corak dan bentuk ROV yang direka secara kreatif dan sesuai digunakan oleh semua komuniti untuk tujuan tertentu. Reka bentuk yang dihasilkan pada setiap bahagian ROV memerlukan penilaian terperinci mengenai keberkesanan fungsi mesin termasuk pegangan atau pencengkam yang berfungsi untuk mengambil atau memegang bahan di bawah air yang disebut sebagai grabber. Pencengkam tersebut boleh melakukan pelbagai tugas seperti penyelamat mangsa lemas, peralatan yang hilang, sampel, serta memegang alat seperti botol pengesan kebocoran, peraturan pengukuran, carabiner talian dan banyak lagi. Mereka direka bentuk menyerupai lengan manusia. Oleh itu, kertas kerja ini menerangkan pengembangan struktur ROV berskala kecil untuk tujuan pendidikan dengan maklumat terperinci setiap bab. Objektif utama kertas kerja ini adalah untuk mengembangkan struktur pencengkam ROV berukuran kecil, membuat pencengkam ROV berskala kecil yang sesuai untuk tujuan pendidikan, dan kemudian mengembangkan pencengkam ROV yang mudah dikendalikan. Reka bentuk akhir pencengkam ROV skala kecil dikembangkan dan dinilai.

ABSTRACT

Various patterns and shapes of ROVs that are creatively designed and suitable for use by all communities for a specific purpose. The design produced on each part of the ROV requires a detail evaluation of the effectiveness of the function of the machine including a handle or rake that serves to pick up or hold a material under water which is called a grabber. The grabber can do various duties such as the recovery of drowning victims, missing equipment, samples, as well as holding instruments such as leak detection bottles, measurement rules, line carabiner and much more. They are designed to resemble a human arm. Thus, this paper describes the development of the grabber structure of small scale ROV for education purpose with detail information of each chapter. The major objectives of this paper were to develop a small size ROVs grabber structure, fabricate a small-scale of ROVs grabber suited for educational purposes, and then develop a grabber of ROV that was easy to manage. The small scale ROV's grabber final design was developed and evaluated.

DEDICATION

My work is devoted to my family and friends. I used to know that any task requires individual work and guidance from all around. Besides this, my family, whose words of support and priests offer me each day a particular feeling of appreciation. This paper also is intended for the ongoing direction, advise, idea, comment and support given to my project's supervisor, Mr. Mohammed Noor Bin Hashim, for my project supervision work. Next, I want to thank my friends who have supported me in the preparation of this project through thick and slim. I also want to thank my family who helped me in my preparation of this project. Last but not least, I also would like to thank you for all my lectures which have supported, encouraged, thought and guided me to complete my project directly or indirectly.



ACKNOWLEDGEMENTS

In the Name of Allah, the Most Gracious, the Most Merciful

I met several amazing folks who greatly helped me complete my job. I want to begin by thanking Ts Muhammed Noor Bin Hashim, my supervisor, for the advice and help he has given us in finishing this assignment. I am very lucky to have a family that is supporting me constantly, when I need it. Furthermore, I pay special tribute to my parents for their lifetime support, prayers and sacrifices. I thank my parents very much because always there all that time for me. Thank you for helping me overcome all the tension and constantly tells me not to renounce. Finally, thank you to all the people who have helped, support and encouraged me to start my studies. I owe my 3BMMA students and especially my group partners and others who are directly or indirectly engaged in this endeavour a lot of appreciation.

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LIST OF SYMBOLS

D, d - Diameter

F - Force

l - Length

m - meter

P - Pressure



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LIST OF ABBREVIATIONS

ROV Remotely Operated Vehicle

HOQ House Of Quality

CNC Computer Numeric Control

3D Three Dimension

AMS Advantage Marine Services (Malaysia)

MBARI Monterey Bay Aquarium Research Institute

WHOI Woods Hole Oceanographic Institution

URI/IFE University of Rhode Island / Institute for Exploration

MCM Mine Countermeasure

SLS Selective Laser Sintering



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CHAPTER 1

INTRODUCTION

1.1 Introduction

An unoccupied subsea robot linked to a vessel by a network of cables is a remotely operated vehicle (ROV). These cables provide control and control signals from the operator to the ROV that enable the vehicle to be operated remotely. An ROV can contain a video camera, lights, sonar, and joint arm. ROVs (Remotely Operated Vehicles) are widespread in the deep-sea industry. The usage of subsea technology has expanded as the oil sector, as well as other key industries, expands into deeper water. Man-powered diving is inconvenient for maintenance and surveys for safety and practical reasons. The idea is to deploy unmanned, highly agile ROVs that are controlled by a human on board a vessel. The ROV is often outfitted with one or more manipulator/ grabber that allow it to execute simple tasks such as pulling cables, opening valves, and handling various instruments. It is critical that the grabbers be easily movable, extremely precise, and have a rapid reaction since this will save money while also allowing for performance. The ROV is often outfitted with one or more grabbers that allow it to execute simple tasks such as pulling cables, opening valves, and handling various instruments. It is critical that the grabbers be easily movable, highly precise, and have a rapid reaction since this will save money while also allowing for the completion of more challenging jobs. Furthermore, the usage of a decent grabber can help to protect the environment. The joint arm is used to pick tiny things, to cut lines or to connect hooks to bigger ones. The manipulator of a ROV or AUV is the most important component of the system. Underwater operations like as grabbing things and manipulating mechanical parts, or twisting handles to lock or open valves, for

example, are impossible to do without a correctly constructed and regulated manipulator. Although numerous ROV applications are employed, some of the most frequent hydrographic applications include item identification and vessel hull inspections (for underwater navigational risks). A ROV is not designed as a replacement for hydrographic inspection but may be a replacement if the divers are not available or the safety of divers is concerned. However, nowadays ROV is utilised for a numbers of analytical applications. In the realm of sea research, they have been very beneficial. They are also utilised in aquaria for educational programmes and for connecting to live on-line research excursions.

1.2 Background

A remotely operated vehicle, usually known as a ROV, is an underwater vehicle that is unmanageable and is connected to the operator in general. An unbroken vehicle is comparable to a robot fitted with sensors and sampling equipment that collect different kinds of data. It operates like a small underwater, except it doesn't have the people. It works wi-fi or wirelessly, although it's more common. A lot of components make up the very complex ROV. A cable network connects the operator to the remotely operated vehicle to allow the ROV to move properly. ROVs are extremely difficult and have a variety of uses. These may be observed in a wide range of fields from exploration and unexpected excursions to study and sport. Offshore, maritime and Renewable Energy businesses, naval defense, water exploration and rescue have been used to repair, maintain and operate undersea operations (researched-based purpose). The ROV is meant to carry out dangerous or destructive activities utilizing predictive, classified and diagnostic algorithms. Other producers, on the other hand, focus on underwater monitoring and

operate for specialized reasons. Furthermore, contemporary technology may be integrated with a remote underwater vehicle to properly monitor and evaluate current temperature, light penetration and water clarity. They are typically used in scientific and exploratory ROVs to learn about the underwater environment. A chemical analyzer will also investigate the specific makeup or composition of the water at various locations and depths. ROVs or under surfaced robots were originally designed to do regular pipeline testing (inside and outside) and to carry out structural testing procedures in diverse offshore locations. Wrecks and old marine water remnants will also be explored with efficient rolling stock. The ROVs meet the demands of a wide array of research missions and aquarium training. The ROV has been engaged in applied training, in maritime organization and usage, and in information, instruments, and strategy research and design as well as in increasing the number of qualified experts working on "important developments in technology" since 1992. ROVs have been used in certain educational endeavors. ROV-based education and activities may be used to promote people's interest in innovation and design expertise. However, no research has been carried out on the effect of the ROV movement or programme, or even the image of innovation and design, on increased study interest. ROVs are also widely employed by scientists to explore the ocean. ROVs have been used to find and study a variety of deep sea creatures and plants in their natural habitat, including the jellyfish *Stella medusa Ventana* and the eel-like allosaurs. Cutting-edge research is conducted at several public and private oceanographic institutions in the United States, including the Monterey Bay Aquarium Research Institute (MBARI), the Woods Hole Oceanographic Institution (WHOI) (with Nereus), and the University of Rhode Island / Institute for Exploration (URI/IFE). ROVs used in science can in a variety of sizes and forms. Because superb video footage is essential for most

deep-sea scientific study, research ROVs are often supplied with high-output lighting systems and broadcast-quality cameras. A scientific ROV will be outfitted with various sample devices and sensors, depending on the research being carried out. Many of these devices are one-of-a-kind, cutting-edge experimental components designed to operate in the harsh environment of the deep ocean. Science ROVs also use commercial ROV technologies, such as hydraulic manipulators and very precise underwater navigation systems. While in military, with 95 percent of the world's trade flowing by sea, the security of our seas, coasts, and inhabitants remains a critical concern for maritime nations. The Deep Trekker Military ROV is assisting EOD crews. Traditionally, EOD teams utilised expert divers to investigate and clear possible underwater minefields. Missions were carried out by a number of assets, from which data was collected, manually analysed, and put together before any further action could be done. As a result, time-consuming processing occurred, placing front-line personnel at danger. Unmanned assets, such as remotely controlled vehicles (ROVs), have been increasingly used for such reasons in recent years. Navies are investing substantially in ROVs to help their EOD crews in difficult situations by conducting Mine Countermeasure (MCM) operations. Until now, these vehicles have mostly been employed to detect, categorise, identify, and locate mines. Military and police personnel who defend our planet rely on powerful technologies to perform their missions as securely and efficiently as feasible. Their equipment include ground robots, aerial drones, and high-tech night-vision gadgets. Deep Trekker is now an alternative for jobs that require underwater examination or inspection.

1.3 Statement of the Purpose

The purpose of the research is to develop the capable grabber of ROV by using mechanical properties such as metal alloys and plastics which is suitable for learning purposes in high school. There are several objectives to achieve the purpose:

1. To develop the concept of an educationally suitable small-scale ROVs grabber module.
2. Fabricate the tiny ROV which is suited for education.
3. ROV easy control and suitable for education purpose.

1.4 Problem Statement

The problem of the design and improvement of the scope of the ROV for training purposes in the grabber construction is lack of design for the grabber due to lack of use. Most ROVs are used only to view underwater conditions where the focus is on the use of cameras and sensors. Therefore, the criteria in the production of the holder or grabber should be studied in depth to meet the suitability of its use. Specific materials are utilised for construction of the underwater manipulators to work in deep seas and to cope with the severe circumstances of the subsea environment. In addition, dependent on the task, the submarine manipulators must comply with the applicable standards for workplace dimensions, lifting capability, wrist torque, etc. Metal alloys such as titanium Ti 6–4, alloys anodized aluminium (5083, 6082 T6, 6061 T6, 7075 T6, A356) as well as plastics are utilised in construction of underwater manipulators and in plastics (Polyethylene). The features of these materials include relatively high strength, resistance to corrosion and excellent processing.

1.5 Project Scope

The scope of this project is to examine all aspects related to the design, structure and construction of the tiny ROV's grabber. The manufacturing process of the ROV's grabber prototype is completed after the investigations, which involves:

1. Easy to manage and educationally acceptable ROV's grabber.
2. Using Selective Laser Sintering (SLS) machine, manufacture ROV body and grabber structure.



CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter collects the project information from newspapers, articles, books, and websites online. The purpose of literature reviews is to provide an overview of the research sources studied throughout the study of a certain problem and how the research notion fits into a broader field of study. It provides an overview of the existing knowledge, which enables relevant concepts, techniques and research requirements to be identified.

2.2 ROV History

Diving people can only dive into specific depths, and depth diving becomes impractical due to the ability and hazard involved. ROVs have evolved into an important instrument for the Offshore Oil and Gas sector, to overcome the limits of human underwater dives. The first robot diving idea was created in the mid 1960s, the Human Occupied Vehicle or HOV. Although partly successful, human fragility restricted HOVs and could not attain the required depths of water. When the first ROV tethered was constructed by Dimitri Rebikoff in 1953, the US military increased its technology in order to recover lost equipment at sea. In 1966, the United States Navy retrieved a nuclear bomb lost during an aircraft accident offshore Spain with a ROV, and a ROV was utilized in 1973 in a submerged submersible offshore Ireland to save seafarers. The U.S. Marine began to build robots at the end of the 1960s to aid identify and restore water preservation. By the 1980s, the use of technology to help the oil and gas sector was started by commercial enterprises. ROV's are now utilized in all forms of investigation and trade,

from dam inspections to evidence retrieval, maintenance of pipelines, aquaculture and retrieval of drowning victims. This advancement was made possible by the good results gained by the new ROV technology, as well as the divers' limits in operating at depths greater than 200 meters.

2.3 ROV in Malaysia

Malaysia Peninsula encompasses a fairly big seaside region. In 2020, ships and other maritime vehicles will be in several ports. The reason for the research is that the underwater portion of the ship that is anchored or ready to be docked does not have to be manually explored. Cracks on the submarine would minimize undesirable risks immediately. Partial underwater exploration is risky and unworkable for humans, particularly in accurate jobs or takes longer to perform the tasks. A ROV is an unmanned robot tethered. In deep-water industries they are used for petroleum and gas exploration, telecommunications, geotechnical research and mineral exploration. Remotely operated Underwater Vehicle may occasionally be termed ROV to distinguish it from the remote-control vehicles that operate on the ground or in the air. Founded in Malaysia in 2008, ROV Resources provides services primarily to the oil and gas industry and underwater, maritime and other associated sectors, for commercial diving and Remotely Operated Vehicles (ROV). The corporation located in Malaysia with the majority of activities in Malaysia. Their services have been expanded since 2010 to Southeast Asian regional markets, with the result that their services, professional knowledge and submarine service experience have expanded. In other hand, Proceanic Engineering Malaysia (part of the Proceanic Group), was granted a task-specific subsea inspections by ExxonMobil Malaysia and Alam Maritim and proved their mini-capacity ROV's to manage pump

pressure adequately in order to clean up marine growth effectively. Then, Advantage Marine Services (Malaysia) In March 2014, Sdn Bhd created the world's leading water service provider. Engages in delivering services defined with the highest quality, safety and cost efficiency. Specialist and intermediate surveys on vessels and plants; class IWS; real-time CCTV inspections; U/W ship maintenance includes hull cleansing, polishing/repairation of the propeller; and undersea repair activities. our experience covers comprehensive air and gas mixing services for commercial diving. In the course of the years, AMS has been diversifying into the manufacture of steel and hosting facilities, industrial cleaning access, engineering control and tools to meet its customers' demands.

2.4 General View Of ROV

Below are the general benefits and inconveniences of ROV system.

Some of the benefits of a ROV are:

1. No time limits (power supplied on board a different vessel)
2. Can cover large regions (relative to capacity of human divers)
3. Mobility offers close-up maritime bed inspection
4. Less limited deployment regions than video towing. Can be utilized in underwater impediment regions.
5. Some models can gather benthic samples (the lower-level biological zone for a body of water like an ocean or a lake)

Disadvantages from ROV such as:

1. Depth range restricted by umbilical cable length.
2. A hard boat is needed to operate the equipment. Cannot get extremely shallow waters.
3. Equipment is highly costly and not widespread.
4. In places with high water currents, it may be difficult to use.
5. The sampling is non-random, such as observation regions, and the operator is picked.

2.5 Power Supply of ROV

The electrical energy loss through the tie is the issue of driving any ROV from the surface. An electric resistance, which has a lengthy connection with thin wires, like the one used for most ROVs, creates a voltage drop proportional to the electric current travelling through the wires. It's ideal to transfer energy at high voltage and low current, limiting power losses, to solve this difficulty. This can be addressed by transferring a standard power to 400 DC by the household (100-240 VAC) to the tether. After the ROV is reached, the power of the 400 volt is dropped to the 15 volts required for powering the ROV. The ROV is replaced by the ROV power supply unit, which carries a 400-volt power supply which is lowered to 15 volts needed by the ROV. It is equipped with a pre-installed power cable and a penetrating signal cable, which replace the original battery tube. The box has two wet-mountable electrical plugs that allow connecting the ROV and disconnecting the ROV from the tether cable. Several studies have found that all factors related to the sort of energy supplied to the immersible, include costs, safety and

necessary performance. Direct current (DC), as well as minimal induction noise, has low cost and weight, which allows less driver protection close to the power line. A separate power source is required for the offshore application. As the vessel's engine drives through power-draining repositioning when the ROV needs more power to escape a dangerous bottom condition, the ROV loses power. Thanks to the independent power source the moving power of the ROV is segregated from the vessel's power needs (Amira & Karim, 2013). Due to the very high-speed thrusters, stable resistance to strong water currents is necessary, which implies that a large quantity of electricity is required by the ROV. The umbilical connection connecting the ROV to the ship provides power, controls and additional information from and to the ROV. This applies to the usually long umbilical cable connecting the ROV to the ship; it can be a few metres wide and is susceptible to significant power dips while being used. As ROVs sink further into the ocean, the industry has a major difficulty of improving power transfer while at the same time reducing the weight of the ROV. The vehicle is powered with a surface power supply in a ROV system. Power may originate from a range of sources including standard electricity or the delivery of DC batteries. AC's supply is first corrected to DC on the surface for the observation-class ROV system, then transferred to the dipower for the thrusters. The 24V DC battery is the power source of the ROV. Because it's a small and cost-effective ROV, the optimum power supply is a DC power supply. This ROV can run on a battery-power combination as well. At its most supported current draw, the microgenerator should be able to supply the system continuous capacity for the anticipated duration.

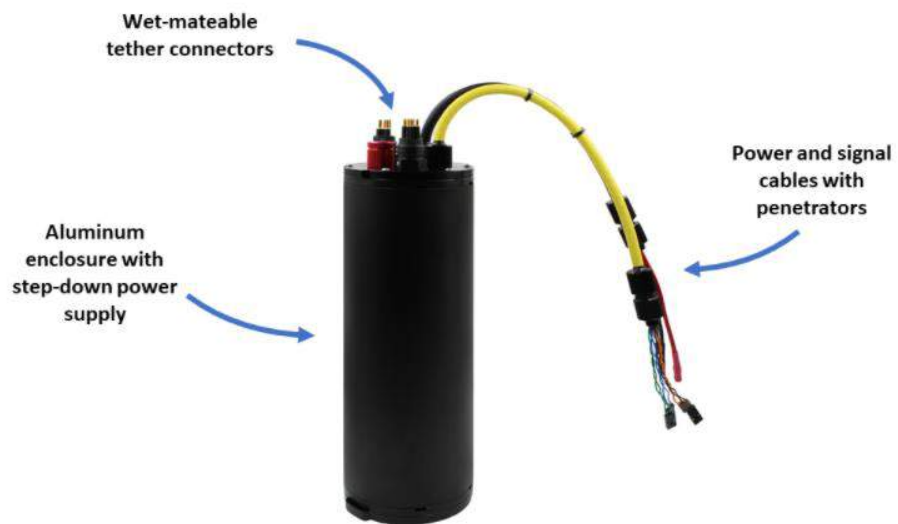


Figure 2.2.1: Power Supply Sample

2.6 The Components of ROV System

2.6.1 Thrusters.

The thrusters are propellers for the electric and hydraulic driving of the vehicle.

Almost typically there are several thrusters for numerous directions of movement.

2.6.2 Camera.

The only vision that the pilot has while the vehicle moves beneath deep sea is from the camera which is capable of providing a low latency image.

2.6.3 Lights.

The lights provide underwater lighting for the camera. The sunlight quickly goes underground and many ROV missions occur deep down in the dark.

2.6.4 Tether.

Virtually all ROVs include an electric power supply and/or signals to the surface, so the pilot can control and view the vehicle. Radio waves do not travel far across the water, hence modern wireless technologies cannot be used in a ROV. Acoustic and optical modem technologies may allow wireless operation one day.

2.6.5 Frame.

The frame offers a structure to fit the thrusters, the camera, the lights, the fasteners and other ROV elements. Although most ROVs have an open rectangular framework that makes construction and modification easy, other ROVs have highly specialised frames designed to reduce drag, improve their look, and perform unique tasks.

2.6.6 Pilot controls.

Surface controls can range from a control room for a spacecraft to an easily accessible device. In any event, the surface controls provide the pilot with a physical interface to drive the vehicle, and display the view of the camera and feedback.

2.6.7 Ballast weight.

To keep the booming of the ROV under control, ballast weight is essential. In order for the centre of gravity to be placed in the correct place, weight and air amount in the ROV must be adequately managed. In the absence of this procedure, the ROV can become imbalanced, leading to rotational motion. It is difficult for the ROV to successfully fulfil its responsibilities in this environment.

2.6.8 Grabber or manipulator.

A most appropriate tool for the performance of subsea interventions. Composed of a succession of rigid bodies (links), linked by revolute joints and appropriate angular displacement between these joints and grippers or other tools attached to an end-effector replaceable. They are frequently accompanied by extra equipment for observing the environment, consisting of one or more cameras and spotlight installed on the submerged car and/or the manipulator itself.

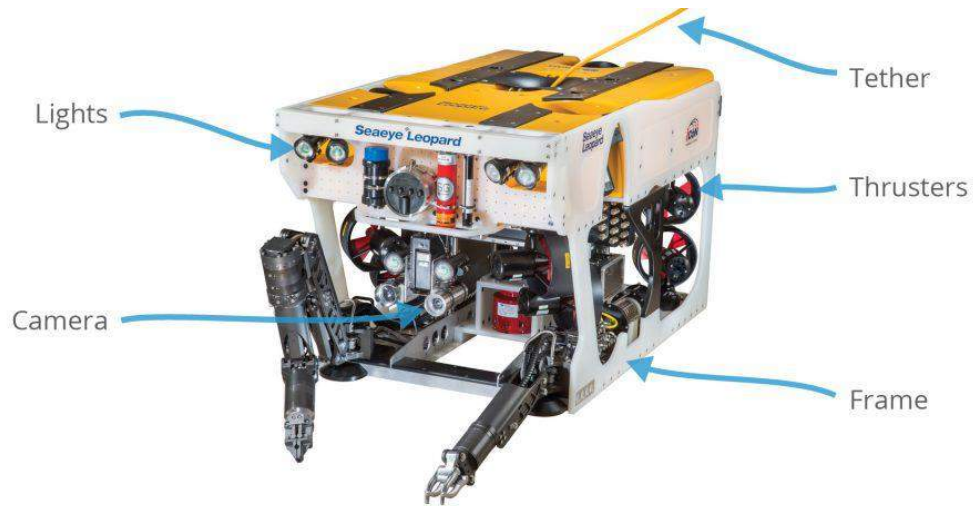


Figure 2.2.2: Basic Components of ROV System



2.7 Mechanical Design for Grabber or Manipulator

Special materials are utilised in the building of submarine manipulators to enable them to function in deep water and to handle the severe conditions of the undersea environment. In addition, depending on the purpose for which they are built, subsea manipulators must comply with applicable criteria for workspace size, lifting capacity, torque of the wrist, etc. Metal alloys such titanium Ti 6–4, aluminium alloys (5083, 6082 T6, 6061 T6, 7075 T6, A356), stainless (316, 630, 660) and certain polymers utilised for the building of underwater manipulators are popular (Polyethylene). The features of the materials include relatively high strength and resistance to corrosion and superior workmanship. Some tests were carried out employing flourishing materials on

underwater manipulators to reduce weight in water and lessen the drive load (Ishimi et al.,1991). Commercially available manipulators for underwater typically range from 3000 to 6500 metres of marine water (msw). Weighing between 6 kg to 150 kg of underwater manipulator (in air), but, its weight in water is more essential, as it defines the buoyancy required on the basic vehicle to offset the manipulator. Weight and dimensions are particularly relevant since the degree of dynamic connection established between the manipulator and the underwater robot on which it is installed is directly accountable and may therefore influence the performance of the entire system. The handler weight must be a low percentage of the entire robot underwater so that it can fully exploit the manipulator's characteristics, in order that the dynamic connecting can be ignored or considered as an external disturbance that can be managed by the dynamic positioning of the underwater robot (if this exists). The weight and the size of the robot thruster system are larger and the robustness produced by the dynamic coupling disturbances are more demanded.



2.8 Type of Actuator in ROV's Grabber

2.8.1 Manipulators Hydraulic.

Hydraulic actuators are generally capable of delivering a significantly bigger output/torque than the force given to the input without the usage of mechanical components such as a gear or a direct drive (direct drive). Hydraulic systems thus have a greater payload ratio, up to the order of three for the existing commercial hydraulic submarine manipulators, whereas that is one or less for the electric one. This is why hydraulic systems are compacter for the same carrying power because they require less parts.



Figure 2.2.3: Hydro-lek 40500R

2.8.2 Electric Grabber.

Electrical submarine manipulators are less common in commercial applications but they are often created for research purposes as prototypes. The typically utilised

actuators are brushless DC (BLDC) electric engines with harmonic transmission gears with a reduced backlash and greater reduction ratio. The actuators are filled with oil, which also offers lubrication and cooling to prevent water entry. Power and signal cables are often fed via the same hoses used for pressure correction to prevent external connections or possible interconnection (Terribile et al., 1994). Ishitsuka and Ishii (2007a) and Ishitsuka and Ishii are experimental prototypes that use magnetic coupling mechanisms to transmit torque to joint as an alternate way to tension (2007b). The fundamental benefit of electrically powered manipulators is that they are capable of accurate movement and are intrinsically equivalent to industrial arms for torque control. However for most industrial jobs electrical subsurface manipulators generally do not fulfil the speed, dependability and force requirements for subseas operations, depending on the nature of the activity (Hildebrandt et al., 2009a).



Figure 2.2.4: Eca robotics 7E

2.9 Manufacturing Process

There are several processes and energy consumption in the manufacturing process. The production process depends on the sequential processing phases, with one step completed leading to the beginning of the following step. Process manufacturers generally rely on tools and software for tracing and programming to ensure maximum operational efficiency.

2.9.1 T.I.G Process

In the 1940s, the soldering of tungsten inert gas (TIG) for the combining of magnesium and aluminium was an overnight success. The procedure was an extremely attractive substitute of gas and manual steel arc soldering with an inert gas shield instead of a slag to protect the weld pool. For high quality welding and structural applications, the TIG has been instrumental in the acceptance of aluminium. In the TIG soiling process, the arc is created in an inert argon or helium atmosphere between the pointed tungsten electrode and the workpiece. The small and powerful arc supplied by the point electrode is perfect for high quality and precise soldering. Since the electrode is not consumed by the welding process, the TIG welder does not have to balance the heat from the arc, as a melting electrode deposits the metal. The soldering pool should be individually added if filler metal is necessary.



Figure 2.2.5: TIG Process



2.9.2 Laser Cutting Process

Laser cutting is one of many processes that in recent years have been much more widely used. Many laser based processes have similar advantages and uses and numerous processes can be carried out with one cutting laser system. This is the method of cutting a material using a laser beam, as the name suggests. This is done in order to either decorate a material or aid it create intricate forms that might struggle with more traditional drills. This procedure has also many parallels with the processes of boiling and graving. The first involves creating thru-holes in materials or teeth like a later method graving. These teeth and hole sizes are essentially cut, which are also used for boiling and graving often in a cutting laser machine. With lasers a wide range of materials and sizes can be cut to make it a handy and adaptable process. The technique goes through the material you are

wanting to cut with a concentrated and precise laser strap to ensure a precise and smooth finish. In the beginning, the beam pierces the material with a hole on the edge, and then the beam continues. The laser essentially melts the material, so it's more like melting than cutting. This means that light materials like linen may easily be cut to tough metals and gemstones like diamonds.

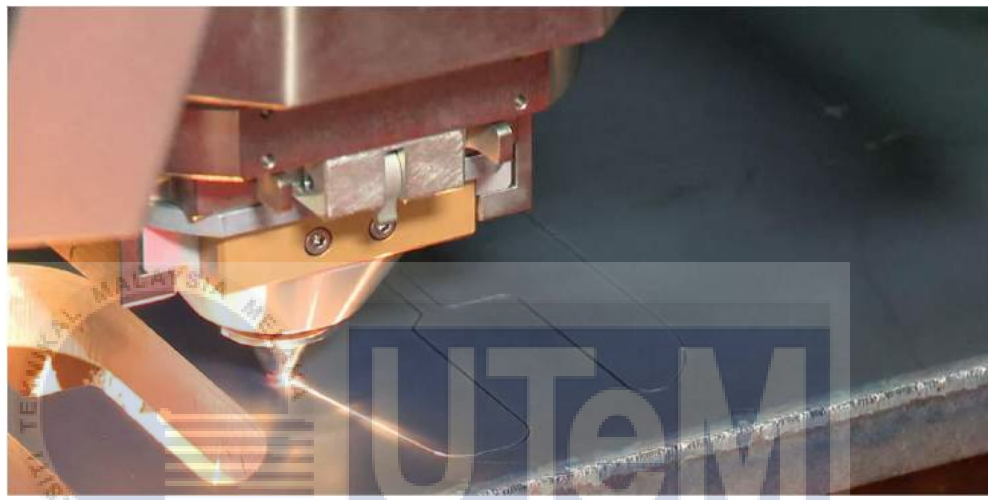


Figure 2.2.6: Laser Cutting Process

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2.9.3 3D Printing Process

3D printing uses CAD to build three-dimensional items using a stacking process. 3D printing includes layering material such as plastic, composite or bio-material to make items of a range of shape, size, rigidity and color. Sometimes known as additive manufacturing. 3D printers are part of the family of additives and employ technologies similar to typical 3D inkjet printers. To make a three-dimensional object from scratch it involves a combination of high-tech software, powder like materials and precision instruments.



Figure 2.2.7: 3D Printing Process

CHAPTER 3

METHODOLOGY

3.1 Introduction

The following flow chart describes the entire project involved. This flow diagram serves as a guideline for the project activities to guarantee that the project aim is met. From literature review to preliminary results, the entire procedure starts. This chapter discusses the way the product is designed and produced. Mechanical needs and engineering concepts are based on number of methods. This section of this chapter examines the design process and the final design of small-scale ROV's grabber.

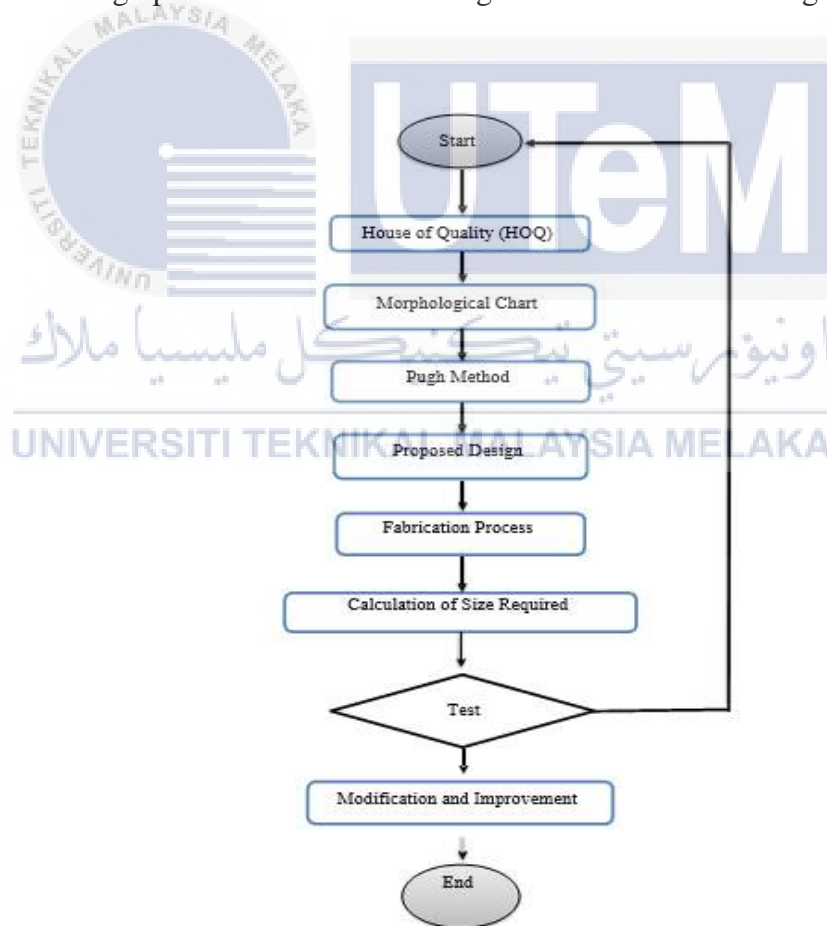


Figure 3.1: Flowchart of the Project

3.2 House of Quality (HOQ)

Refer to figure above, the HOQ is characterized as a product planning matrix, which demonstrates how consumer criteria directly link to the techniques and methods that firms might employ to meet these requirements. House diagrams employ a design similar to the outline and can be generated utilizing technical and competitive benchmarking information. HOQ is considered the major instrument used to facilitate group decision-making throughout the quality function implementation. Profits of constructing a quality house include establishing consumer demands and specifications, then building and prioritizing services and products. The House of Quality (HOQ) was an instrument for critical thinking or a result of development or improvement. The HOQ approach focused throughout the whole process on the fulfilling project requirements. It also thoroughly recognizes or identifies the component for all standards, including product ergonomics and engineering features.

From the figure, some criteria have been split into four digits as rating marks for the many sorts of criteria that have been provided. The total number of ratings is evaluated, and the top three are chosen as the primary source of reference for the project. Those are chosen by evaluate the important ranking which is refer to the relative weight score. The higher score is defined as best top three criteria that are suit with this project.

House of Quality for grabber of small-scale ROV

Importance Rating:

1 = Low Importance

3 = Moderate Importance

5 = High Importance

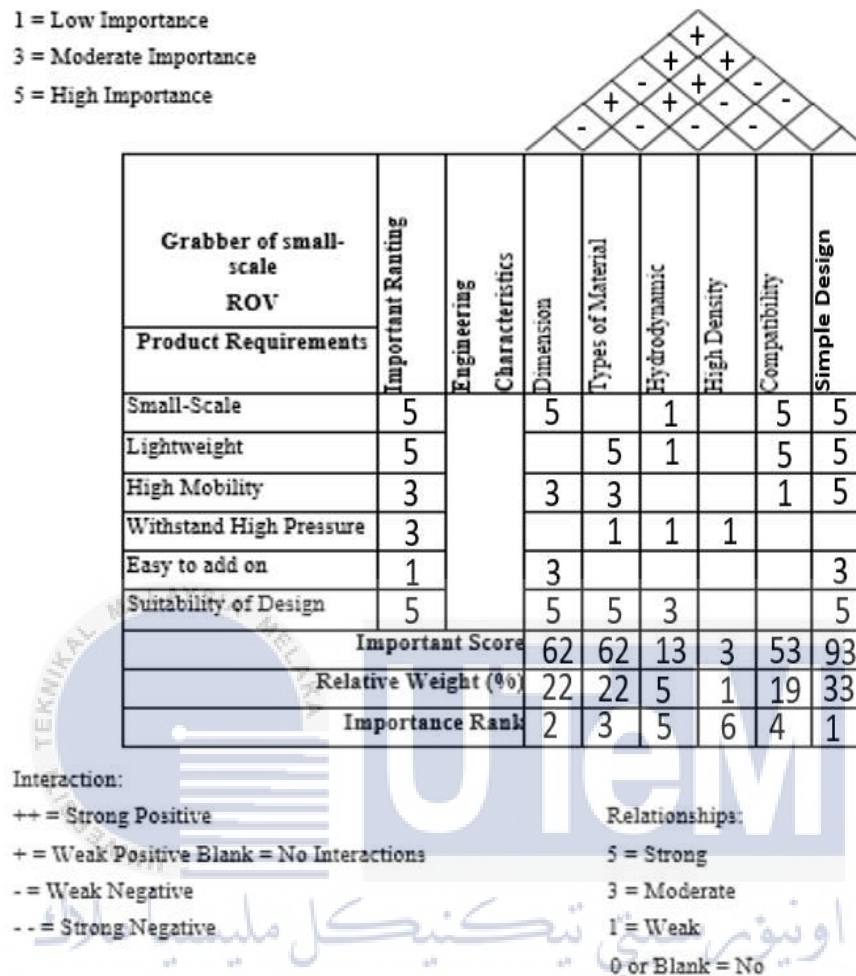


Figure 3.2: House of Quality

3.3 Morphological Chart

A Morphological Chart is a process by which a product/solution can then be independently studied and devised. Those ideas can afterwards be blended and adapted to generate other solutions also recognized as a method of analytically and systematically generating ideas. A morphological chart is a diagrammatic process for cataloguing

combinations of alternative system elements and for assessing them. besides that, this chart also functions as a visual technique of capturing the required product features and exploring alternate methods and combinations to achieve this feature. A variety of potential solutions may exist for each member of the product function. The chart gives the opportunity to express these ideas and a structure for the consideration of alternatives.

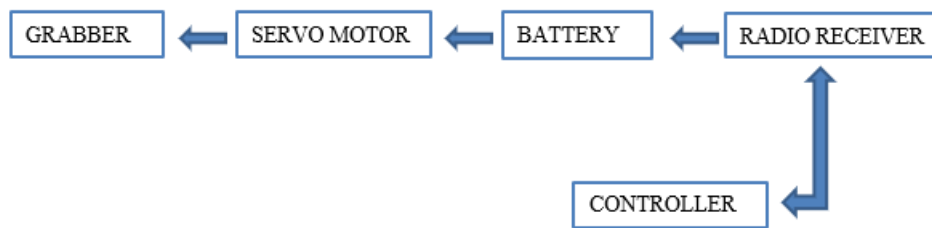



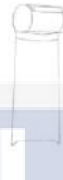
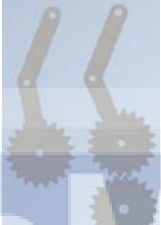
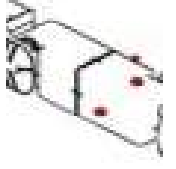


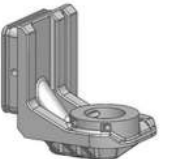


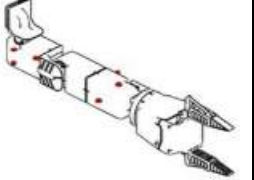




Figure 3.3: Grabber Technical Programme

From the table 1 below, a grabber for this ROV will require numerous components to be explored. Claw, connection, base, servo motor, battery, radio receiver, and controller are examples of these components. Claw, connection, and base are significant components in the design of grabber items that contribute to the revenue of grabber products. The grabber should be manufactured in accordance with the study's objectives, with a size that is optimistic and appropriate for the ROV's body. The radio receiver, servo motor, controller, and battery are critical components for moving the grabber as shown in Figure 10.

Table 3-1: Morphological Chart

Variant No	Sub Function	Sketching		
		1	2	3
a	Claw	Double-pair Claw 	Single Claw 	Double-pair sharp Claw 
b	Connector	Rounded Connector 	Gear Connector 	Rec-shape Connector 
c	Base	Headed Base 	Plane Base 	Bridge Base 
d	Overall Grabber			
e	Servo Motor	MG996R 360 	MG995 360 	

3.4 Pugh Method

By evaluating the mean score of concepts, the Pugh technique is utilised to determine several criteria. The idea comes from the morphological chart, in which the conceptions concerning the character of the item were developed. The weight of the idea to be authorised is the most essential factor. The Pugh technique is used to examine several criteria by calculating the absolute score between ideas or concepts. The notion derives from the morphological diagram of the product's characteristics. The concepts are considered. This method also known as a quantitative method used to classify the optional multidimensional options. It is often used to make design decisions in engineering but may also be used to rank investment alternatives, supplier options, product options or any multidimensional group of entities.

From the table below, we may compare the three designs to a pre-existing design known as a datum. The comparison is based on several factors. The elements that serve as the foundation for comparison are the design's simpleness, easy-to-shape proportions, and the sort of material that best meets the project's aims. The final results on the calculations performed based on the table format below show that the second design provides more features that are in line with the main objectives of this study where it requires the concept of an educationally suitable small-scale ROVs grabber module, easier to fabricate the tiny ROV which is suited for education and ROV easy control and suitable for education purpose.

Table 3-2: Pugh Method

	Engineering Characteristic	Weights	DATUM	Design1	Design2	Design3
1	Simple Design	5		+	++	-
2	Dimension	5		+	++	--
3	Type of Material	5		-	+	+
	Total +			2	5	1
	Total -			1	0	3
	Overall Score			1	5	-2
	Weighted Total +			10	25	5
	Weighted Total -			5	0	15
	Weighted overall Score			5	25	-10
Scale						
-	Worse					
--	Much Worse					
s	Same					
+	Better					
++	Much better					

3.5 Selected Design

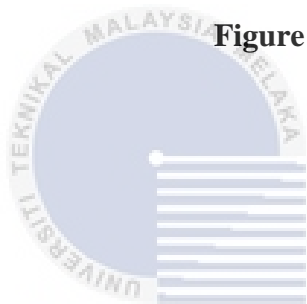
The proposed design concept for the service module of the Mini ROV' grabber is to develop and draw out an overview of the product design using the software of Inventor to reach satisfaction based on Pugh method's final weight, followed by testing of the design. The design of the ROV grabber was based on a comprehensive assessment taking into consideration the mechanical properties of each material. Several variables were explored before to deciding on the design. In order to guarantee they function together seamlessly, for example, the size of the grabber must match the body structure.

3.5.1 Grabber Material

After overall consideration, the selected material for this grabber is Nylon, a highly competent engineering thermoplastic for both functional prototype and end-use manufacturing, is the most often used material for selective laser sintering (SLS). Nylon is great for complicated assemblies and long-lasting parts that require little maintenance, which is suit to the underwater condition. Here is some definition of Nylon. SLS 3D printed nylon items are robust, rigid, solid, and long-lasting. The finished pieces are impact-resistant and can withstand repetitive wear and tear. Nylon is resistant to UV, light, heat, moisture, chemicals, temperature, and water. 3D printed nylon components can also be biocompatible and non-sensitizing, which means they are ready to wear and safe to use in a variety of settings. Nylon is a synthetic thermoplastic polymer that belongs to the polyamide family. Nylon's elasticity and durability aid in 3D printing objects with thin walls. Its low coefficient of friction combined with a high melting point makes it particularly resistant to abrasion and allows it to be utilized in printing for items such as functioning interlocking gears. Nylon has been a popular material for use with 3D printers in the same manner that it has become a go-to material in traditional manufacturing. 3D printing has the extra benefits of infinite geometries, iteration and customization, and low-volume pricing. There's a lot of benefit using this material but these explanations are enough to prove that all of the suitability of the material for this grabber.



Figure 3.4: Nylon ROVs Grabber



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3.5.2 Grabber and Connector Design

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The design for this chapter is done by hand drawing before selecting the best design. Many designs were taken throughout the course of the investigation, but just a simple one were chosen to be the major designs in this project. This design was chosen based on the consensus of the outcomes of talks during the project's implementation, as well as specific criteria. To enhance learning sessions, a lightweight design and a not-too-large size are required for greater learning appropriateness. This product's use in higher education is not very rigorous, and it is only used sparingly for demonstration.

Grabber Design



Figure 3.5 Grabber

Grabber's Claw Design



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Figure 3.6 Claw

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Connector Part Design



Figure 3.7 Connector Part

Overall Connector Part design

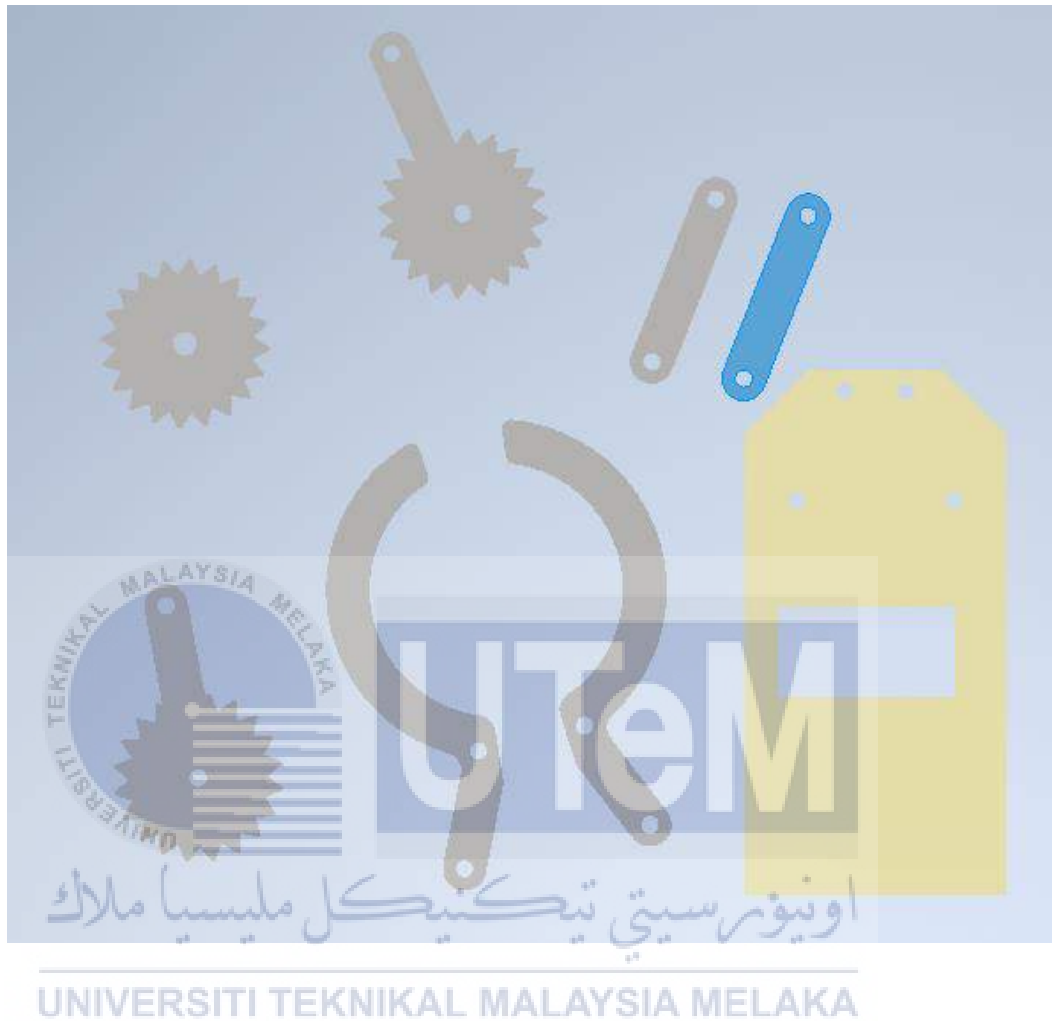


Figure 3.8 Overall Design

3.5.3 Dimension of Grabber and Connector

At least one manipulators must be fitted to the vehicle. On the port side there is a grabber and on the starboard side there is an operational manipulator. The measures designed are based on the appropriateness of the ROV body construction that is for the

learning of accurate, easy to install and open-top features which are perfect in size and lasting in every circumstance.

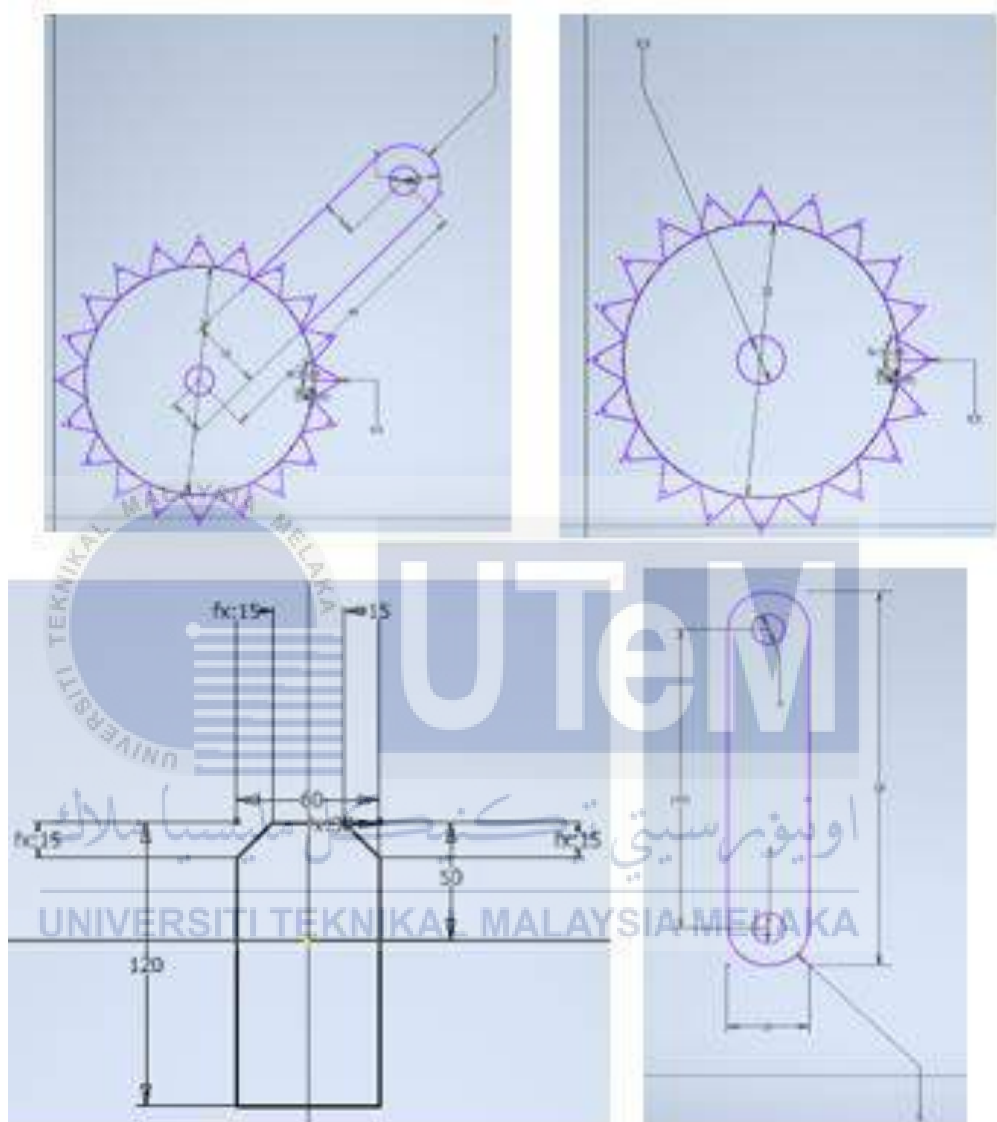


Figure 3.9: Dimension Grabber and Connector

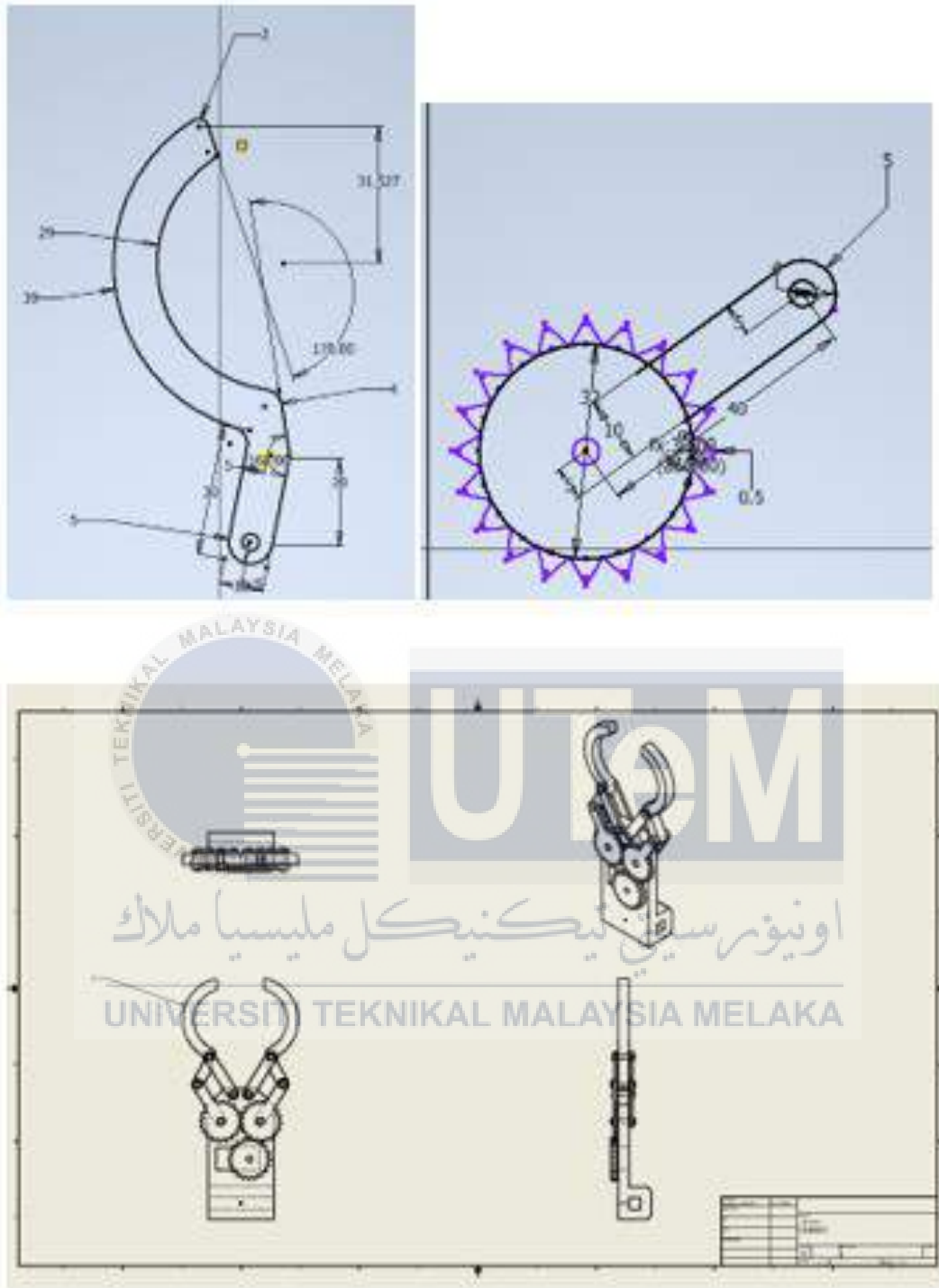


Figure 3.10 Dimension Grabber and Connector

3.5.4 Dimension of Servo Motor



Figure 3.11: MG995 360

We chose this type of servo because it has advanced internal circuitry that delivers strong torque, holding power, and rapid updates in reaction to external stimuli. TowerPro MG995 Sem-Metal Gear Servo Motors are high-speed servo motors with a massive torque of 10 kg/cm. This common high-speed servo can spin around 120 degrees (60 in each direction). The servo is well-suited for creating robotic arms with severe motor wear and tear. Because it is metal geared, the servo has a long life and may be used in systems such as robotic arms where the motor work is extensive. Because of how simple it is to operate these servos using any servo code, hardware, or library, it's great for beginners who want to make things move without having to develop a motor controller with feedback and a gear box, especially because it fits in small dimensions.

Here is some specification of this servo where we get from the suppliers.

- Weight: 55 g
- Dimension: 40.7 x 19.7 x 42.9 mm approx.

- Stall torque: 8.5 kgf·cm (4.8 V), 10 kgf·cm (6 V)
- Operating speed: 0.2 s/60° (4.8 V), 0.16 s/60° (6 V)
- Operating voltage: 4.8 V a 7.2 V
- Dead band width: 5 μ s
- Stable and shock proof double ball bearing design
- Temperature range: 0 °C – 55 °C

Servo Dimension

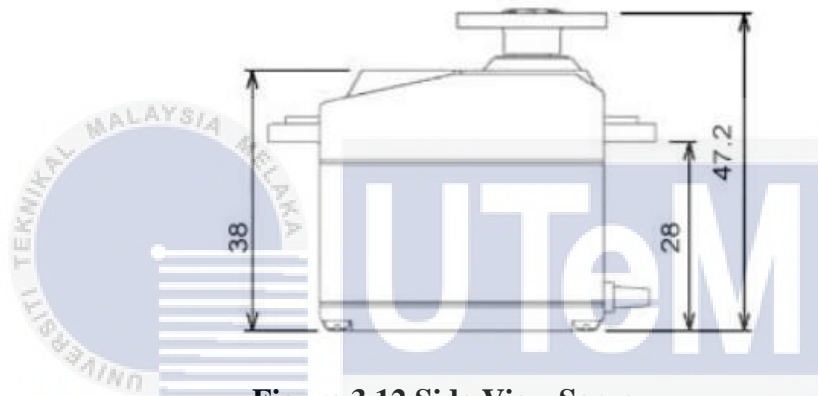


Figure 3.12 Side View Servo

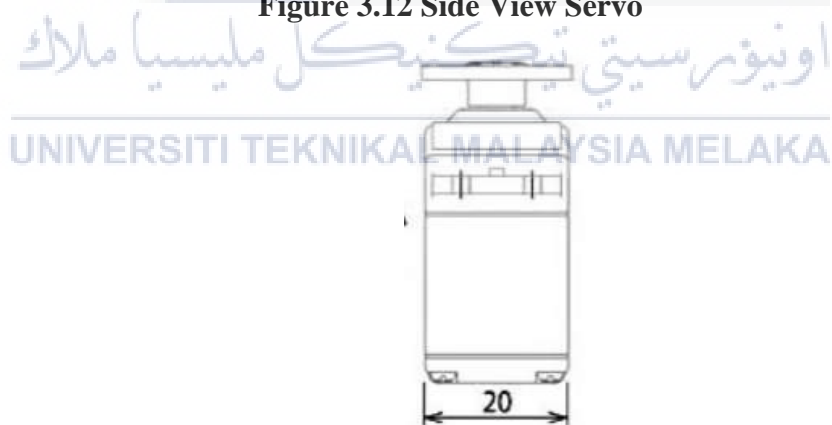


Figure 3.13 Front View Servo

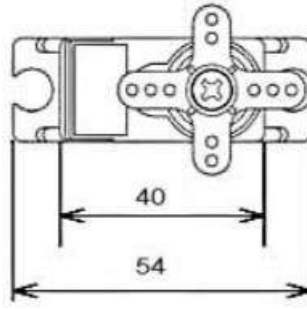


Figure 3.14 Top View Servo

CHAPTER 4

RESULT AND DISCUSSION

4.1 Overview

The ROV's grabber was judged to be the optimal design and suitable for teaching because of its mechanical properties and easy production. Most earlier researchers or manufacturers have created a grabber for tiny ROVs, and compared to a previous form, the production method of a grabber has been quite easy. This research aims to identify the optimal shape of the ROV's grabber, and the material utilized as materials are a key role in underwater pressure and booster force. The major objective of the project was the development of ROVs with a simple grabber appropriate for training and cheap for schools.

4.2 Experimental Work and Result

As shown in figure below, some faults in the components have occurred during the first try at 3D printing. Among the flaws is that each component of the grabber is mounted directly to the base. Because there is no clearance between each component and the base that permits it to move, the grabber does not function correctly and cannot grip. So, we decided to adjust the clearance by using the Inventor.



Figure 4.1: Defect Grabber

For the second try, the component and the base are too far away, causing the grabber grasp to become loose and unstable. This is due to the fact that the amended clearance on the inventor's drawing is excessive as shown in figure below.

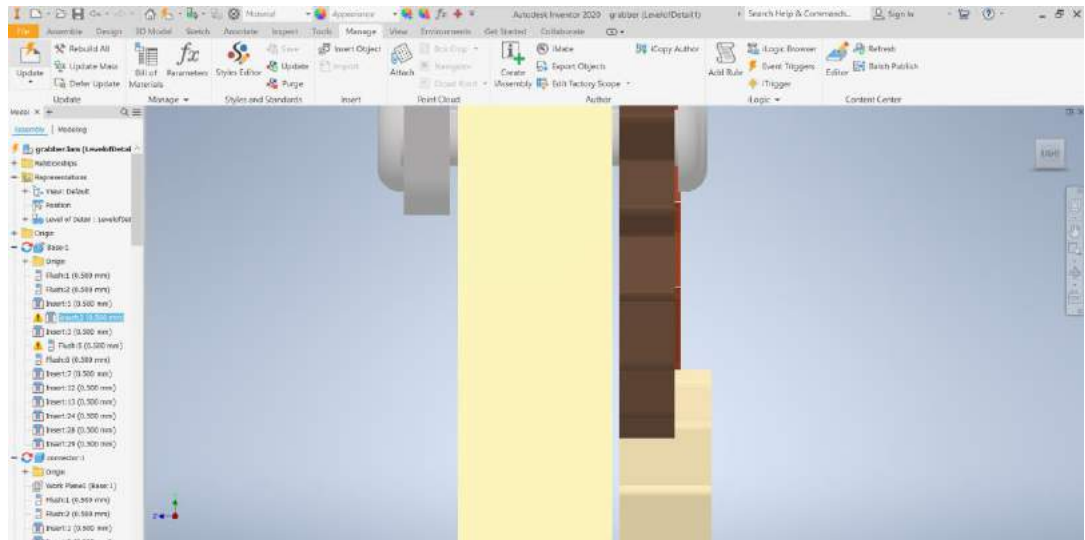


Figure 4.2: Error Clearance

To fix the problem, each component is riveted to the base, allowing the grabber to hold effectively.



Figure 4.3: Final Grabber

4.2.1 In-water Result

A preliminary experiment was carried out under realistic settings to test the suggested arm. The test intends to assess the manipulator's precision while reaching predefined positions both within and outside of the water. Because the grabber was developed for the underwater environment, when it functions on land, it poses significant limits in movement to achieve desirable positions, particularly when travelling upward, due to its weight.



Figure 4.4 Underwater Test

The in-water test was carried out in a water tank with the underwater manipulator mounted to a fixed platform. A calibrated camera enclosed in a waterproof casing detects a passive marker put on the end-effector and, by combining these data with the arm's kinematic model, allows the end-posture effector's to be measured.

4.3 Data Analysis of the Grabber

4.3.1 Grabber

The underwater manipulator's physical prototype was created using additive manufacturing methods. Selective Laser Sintering (SLS) has been used to create the polymeric components, such as the arm's modular pieces and the gripper's adaptable fingers. As mentioned in the study's goal, the production of this grabber is for educational purposes in schools, where this ROV will only be used in shallow water locations with less than one meter of water level. Loads linked with light trash such as plastics, empty cans, and polystyrene left in the water were studied. Such materials, in course, do not weigh more than one kilogram. As a result, the loads or pressured used in the analysis are only 0.5, 0.8, and 1.0 kg. So here is some Finite Element Analysis (FEA) of the grabber to pick up several item in various weight. The pressure is applied at the tip of the claw, where the highest region is used to grab and retain an element.

1. Displacement Stress Analysis

The displacement-based finite element method's primary goal is to compute the displacement field within a solid exposed to external forces. Visualize a solid deforming under external loads to make this more exact. As the load is applied, every point in the solid shifts.

1. Weight of 5 Newtons / 0.5-kilogram force



Figure 4.5: 5 Newton load for Displacement Stress

2. Weight of 8 Newton / 0.8-kilogram force



Figure 4.6: 8 Newton load for Displacement Stress

3. Weight of 10 Newton / 1-kilogram force



Figure 17: 10 Newton load for Displacement Stress

2. Normal Stress Analysis

A normal stress is one that happens when an axial force is applied to a part. The force divided by the cross-sectional area equals the normal force for any prismatic section. When a member is in tension or compression, it experiences normal stress.

1. Weight of 5 Newton / 0.5-kilogram force



Figure 4.7: 5 Newton load for Normal Stress

2. Weight of 8 Newton / 0.8-kilogram force

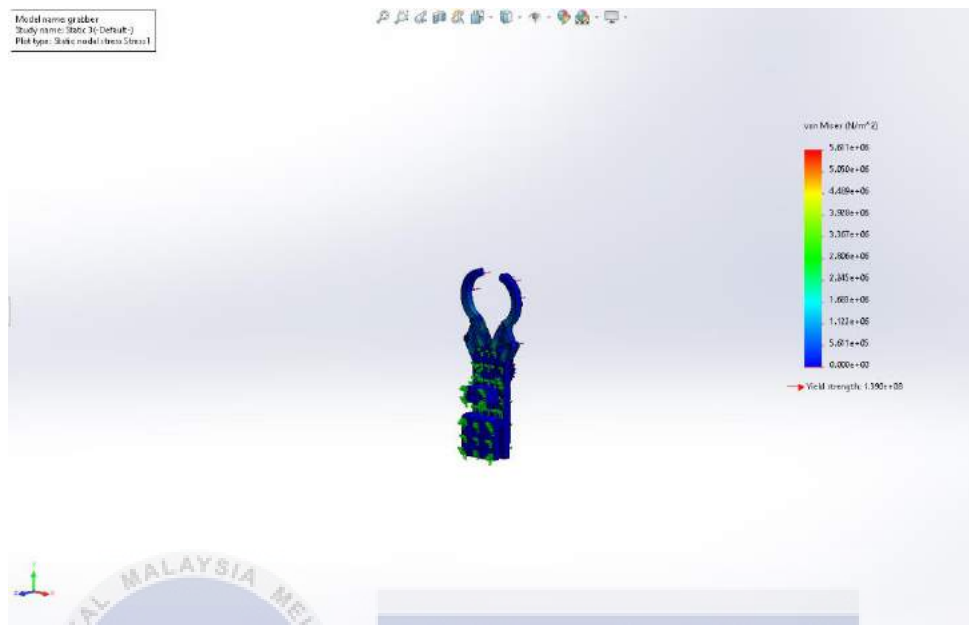


Figure 4.8: 8 Newton load for Normal Stress

3. Weight of 10 Newton / 1-kilogram force

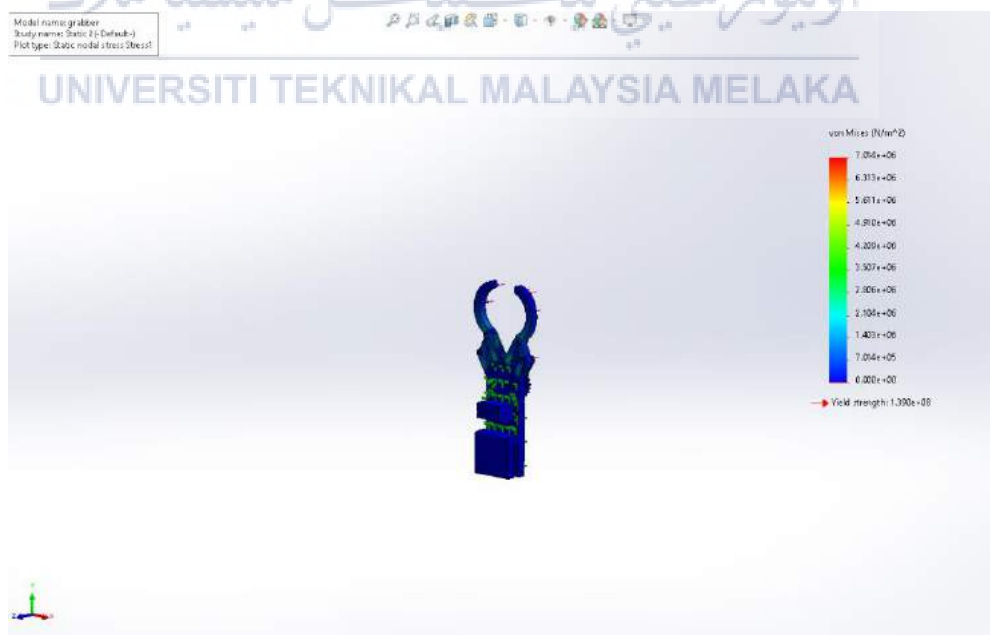


Figure 4.9: 10 Newton load for Normal Stress

3. Normal Strain Analysis

Normal strain is symbolised by the Greek letter epsilon and occurs when an item elongates in response to a normal tension (i.e. perpendicular to a surface). A positive score indicates tensile strain, whereas a negative value indicates compressive strain.

1. Weight of 5 Newton / 0.5-kilogram force



Figure 4.10: 5 Newton load for Normal Strain

2. Weight of 8 Newton / 0.8-kilogram force



Figure 4.11: 8 Newton load for Normal Strain

3. Weight of 10 newton / 1-kilogram force



Figure 4.12: 10 Newton load for Normal Strain

4. Factor Of Safety

All parts of a design, as well as how the design will be used, are subject to some degree of uncertainty. You must always use a Factor of Safety for all of the reasons stated above (FOS). It's referred to as the "factor of ignorance" by some designers. It's important to remember that a FOS of unity indicates that failure is imminent, not that a part or assembly is safe.

1. Weight of 5 Newton / 0.5-kilogram force



Figure 4.13: 5 Newton load for FOS

2. Weight of 8 Newton / 0.8-kilogram force

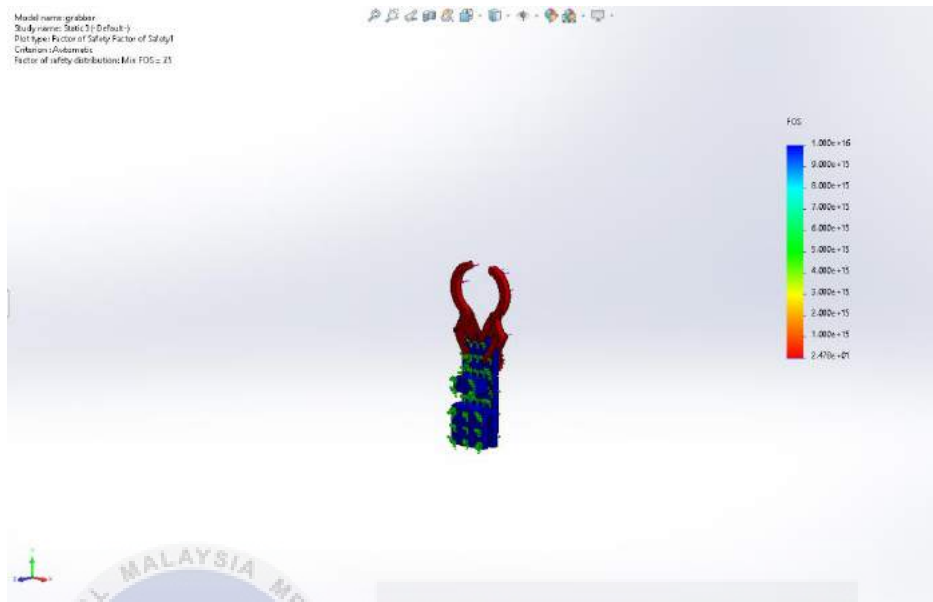


Figure 4.14: 8 Newton load for FOS

3. Weight of 10 Newton / 1-kilogram force



Figure 4.15: 10 Newton load for FOS

Based on the analysis, the grabber is capable of withstanding the specified load without issue. As a result, it is possible to infer that the material used is appropriate for the manufacturing of this product and is consistent with its intended usage as an underwater machine.

4.4 Cost Analysis

The following is a list of the expenditures incurred throughout the course of this project's success. Each student has been allotted RM200.00. As a result, we must deduct the surplus capital from the budgeted amount for electronic products for programming in order for the ROV system, including Grabber, to run and function effectively.

Table 4-1: Cost Analysis

Cost Analysis			
Product	Quantity	Cost	Total Cost
JJRC1 12 -24 V 20A Brushless Motor 4 Blade	3	RM58.67	RM176
Waterproof Camera Sport Camera SQ29	1	RM50.59	RM50.59
Battery 11.1V 2200mAh LiPo Rechargeable Battery	2	RM75	RM150
Air Tight Food Keeper E-1632 1000 ML	1	RM4.90	RM4.90
FLYSKY 16X Transmitter	1	RM240	RM240
FSIA6B Receiver	1	RM58	RM58
HOBBYWING SKYWALKER 40A ESC	3	RM50	RM150

PDB- 006 35 X 35	1	RM5	RM5
XT60 STANDARD	1	RM4	RM4
USB HEADLIGHT BL-8102	1	RM15.70	RM15.70
MG946R METAL GEAR SERVO	1	RM29	RM29
TOTAL	-	-	RM883.19



CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

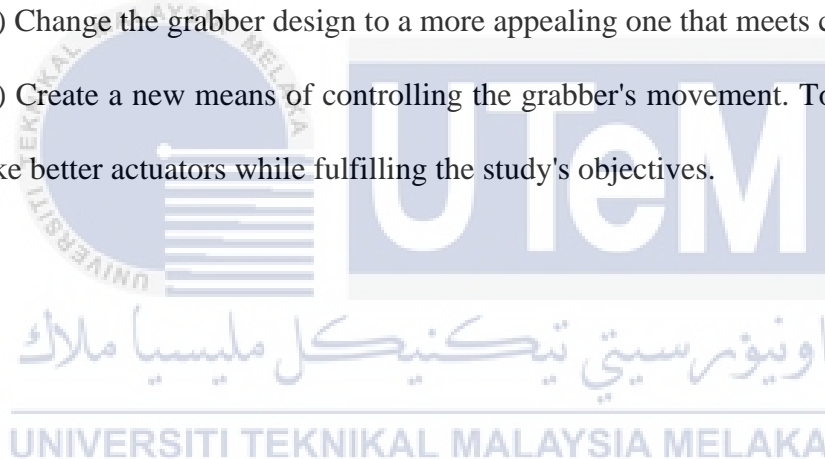
5.1 Conclusion

To summarize, the goal of this report was to show the research and development work that went into designing and simulating a ROV's manipulator or grabber. The grabber's design and simulation were carried out as part of a ROV mission. This work has offered some novel solutions for the field of underwater manipulation. Using contemporary additive manufacturing technology, a lightweight modular underwater grabber that can be placed on small size ROVs has been conceived and prototyped. The underwater manipulator is outfitted with an adaptable gripper that was created using selective laser sintering (SLS) technology to reduce the number of components while increasing the arm's flexibility. An entire chapter was also devoted to introducing the features of the electronic programming system. When building the interface system, having a basic grasp of the subject might be advantageous. In addition, the investigation revealed that a redesign of the control system and supporting structure, as well as the use of more powerful servos, are necessary to improve the overall performance of the system. Furthermore, additional experiments, such as static and dynamic testing on more complicated robotic arm configurations, must be carried out in the underwater environment.

5.2 Recommendation

The work described in this report is far from accomplished. There are still a lot of possible areas for development, such as optimizing the arm design, the manipulator's guidance and control system, and its kinematics. Furthermore, various simplifications were implemented in order to run the simulation, which may have a substantial influence on the correctness of the simulation findings. A comprehensive manipulator system is projected to deliver greater precision. The time allocated to make this product is relatively limited, making it difficult to generate a high-quality product. Among the things that may be added to this project are:

- 1) Change the grabber design to a more appealing one that meets certain criteria.
- 2) Create a new means of controlling the grabber's movement. To put it another way, make better actuators while fulfilling the study's objectives.



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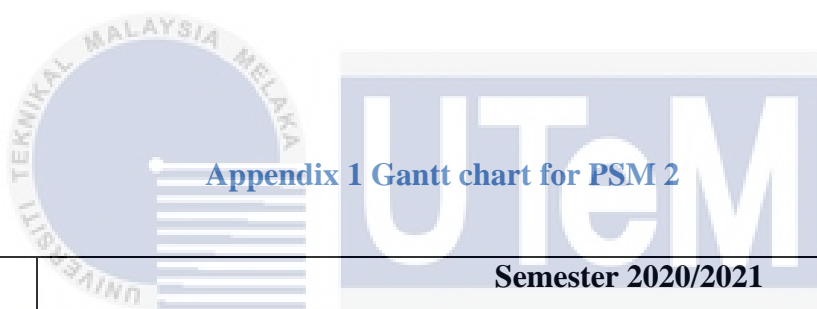


APPENDIX

Appendix A Gantt chart for PSM 1

	Semester 2020/2021																			
Project Activity	Week																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Title & supervisor Selection																				
Research for proposal																				
Submission of project proposal																				
Project literature review																				
Identify project methodology and working principle																				
Project report writing (Draft: Chapter 1-3)																				
Submission of project draft report																				
								Mid Term Break								Study Week	Final Semester Examination			Semester Break

Finalize draft report and correction repair																				
Report submission																				
Video presentation																				
Presentation for PSM1																				



Project Activity	Week																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
First meeting with SV																				
Discussion on report repairing																				
Discussion on testing date at FTKMP																				



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PENGKELASAN TESIS SEBAGAI TERHAD BAGI TESIS PROJEK SARJANA MUDA

Dengan segala hormatnya merujuk kepada perkara di atas.

2. Dengan ini, dimaklumkan permohonan pengkelasan tesis yang dilampirkan sebagai TERHAD untuk tempoh **LIMA** tahun dari tarikh surat ini. Butiran lanjut laporan PSM tersebut adalah seperti berikut:

Nama pelajar: IKHMAL HAKIMI BIN ABDUL JALIL (B091810446)

Tajuk Tesis: DEVELOPMENT OF GRABBER STRUCTURE OF SMALL SCALE ROV FOR EDUCATION PURPOSES.

3. Hal ini adalah kerana IANYA MERUPAKAN PROJEK YANG DITAJA OLEH SYARIKAT LUAR DAN HASIL KAJIANNYA ADALAH SULIT.

Sekian, terima kasih.

“BERKHIDMAT UNTUK NEGARA”
“KOMPETENSI TERAS KEGEMILANGAN”

Saya yang menjalankan amanah,

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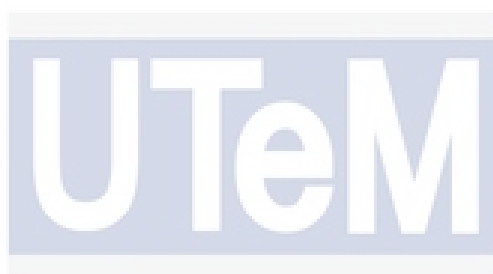
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