DESIGN AND FABRICATION ON WATERBIKE FLOATING SYSTEM

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in fulfillment of the requirements for the degree of
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DECLARATION

I declare that this bachelor's degree project entitled "Design and Fabrication of Water Bike Floating System" is the result of my own research except as cited in the references. The bachelor's degree project has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ....

Name : MUHAMMAD AKMAL FARHAN BIN TUAH MARZUKI

Date : 1/1/2025

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 Degree Mechanical Engineering Technology (Automotive) with Honours.

Signature : ....

Supervisor Name : Ir. Ts. Dr. Mohamad Hafiz Bin Harun

Date : 1/1/2025

DEDICATION

This thesis is dedicated to my parents, for their endless love, support, and encouragement throughout my academic journey. Their belief in my potential has been a constant source of inspiration.

I also dedicate this work to my advisor, Dr. Hafiz, whose invaluable guidance, wisdom, and patience have helped in completing this thesis. Your dedication to my success has had a profound impact on my academic and personal growth.

To my friends and colleagues, thank you for your unwavering support, insightful discussions and warmth. Your encouragement and friendship have been invaluable throughout this journey.

ABSTRACT

Water bikes have become popular these days. Water bikes are used in tourism activities, and some even use them for rescue purposes. This project is targeted at students in rural areas who have to cross the river to go to school. This bike is a versatile usage. This is because they just have to pedal the bike as usual on land and when they arrive at the river area, they just have to open the float to pedal on water. The process of opening this float is easy. Therefore, a project was carried out for the design and fabrication of a bicycle on water that has a floating system that has characteristics such as portability and ease of use. The method of this project follows all the organized processes that make this project run successfully. Starting with an in-depth study of the concept of a project that has been made before. The concept then was processed and upgraded to form a water bike that is low cost and safe to use. CATIA V5 is carried out to simulate stress analysis on the critical part of the water bike. In addition, some calculations were also made to support the certainty that this project is able to float according to the weight that has been set. A mockup prototype was also created to facilitate the real actual design of this project. The production method of this project involves the process of cutting, drilling, welding and finishing. The main material used in this project is hollow steel and PVC pipe. Analysis of frame structure states the maximum Von Mises stress of 183 MPa, lower than the yield strength of steel, 250 MPa. Results of factors of safety (FoS) calculations show that the frame operates well within the safe and pass stress limit, 1.37. Floating test on PVC is successful on the water with the mass of the bike, 35 kg and the rider, 70 kg. Result shows the available volume produced 0.138 m^3 is greater than required volume 0.105 m^3.

ABSTRAK

Basikal air telah menjadi popular hari ini. Basikal air digunakan dalam aktiviti pelancongan, malah ada yang menggunakannya untuk tujuan menyelamat. Projek ini disasarkan kepada pelajar di luar bandar yang terpaksa menyeberangi sungai untuk ke sekolah. Basikal ini serba boleh. Ini kerana mereka hanya perlu mengayuh basikal seperti biasa di darat dan apabila tiba di kawasan sungai, mereka hanya perlu membuka pelampung untuk mengayuh di atas air. Proses membuka pelampung ini adalah mudah. Oleh itu, projek reka bentuk dan fabrikasi basikal di atas air telah dijalankan yang mempunyai sistem terapung yang mempunyai ciri-ciri seperti mudah alih dan mudah digunakan. Kaedah projek ini mengikut semua proses yang teratur yang menjadikan projek ini berjalan dengan jayanya. Dimulakan dengan kajian mendalam tentang konsep projek yang telah dibuat sebelum ini. Konsep itu kemudiannya diproses dan dinaik taraf untuk membentuk basikal air yang kos rendah dan selamat. CATIA V5 dijalankan untuk mensimulasikan analisis tekanan pada bahagian kritikal basikal air. Selain itu, beberapa pengiraan juga dibuat bagi menyokong kepastian projek ini mampu terapung mengikut berat yang telah ditetapkan. Satu prototaip juga telah dicipta untuk memudahkan reka bentuk sebenar projek ini. Kaedah penghasilan projek ini melibatkan proses pemotongan, penggerudian, kimpalan dan kemasan. Bahan utama yang digunakan dalam projek ini ialah keluli berongga dan paip PVC. Analisis struktur rangka menyatakan tegasan Von Mises maksimum 183 MPa, lebih rendah daripada kekuatan alah keluli, 250 MPa. Keputusan pengiraan faktor keselamatan (FoS) menunjukkan bahawa bingkai beroperasi dengan baik dalam had tegasan selamat dan melepasi, 1.37. Ujian terapung pada PVC berjaya di atas air dengan jisim basikal, 35 kg dan penunggang, 70 kg. Keputusan menunjukkan volum tersedia yang dihasilkan 0.138 m^3 lebih besar daripada volum yang diperlukan 0.105 m^3.

ACKNOWLEDGEMENTS

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

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LIST OF SYMBOLS AND ABBREVIATIONS

CAD	-	Computer Aided Design
FTKM	-	Fakulti Teknologi Kejuruteraan Mekanikal
3D	-	Three-Dimensional
CATIA	-	Computer Aided Three-dimensional Interactive Application.
AV	-	Amphibious Vehicle

CHAPTER 1

INTRODUCTION

1.1 Background

Amphibious vehicles have been thought of and have been made by previous people. This is because of the need for vehicles that can operate on land and on water. Hull of the vehicle is often designed according to the shape of a boat that provides stability and buoyancy. The hull is usually made of light and strong materials such as fiberglass, aluminum and composite materials. This amphibious vehicle is usually used for tourism and adventure sports. In the military it is also often used, which makes it easier for them to move from land to water for rescue or military purposes. Amphibious vehicles also have a more complex design and engineering than other vehicles.

The initiation of the idea of making an amphibious bicycle was thought of because of its simpler design and low cost. Small size but towards the same purpose and goal as other amphibious vehicles, it has become a request for many parties. This amphibious bike is a concern when it is able to be a source of income for an organization by making it as a recreational activity, adventure sport and rental purpose. Its movement uses propulsion and navigation while the pontoon is used as a tool to make it float. Its ability to move on water and land makes the price of this amphibious bike much more expensive than a regular bike.

The purpose of amphibious bicycles is to create a flexible and environmentally responsible form of transportation. In addition, it can also go from land to water with ease. This invention improves leisure activities and adventure sports. It runs entirely on human power. Furthermore, in areas prone to flooding, amphibious bikes are very useful for emergencies and rescue operations. The main creation of the water bike in this project which focuses students on the countryside to help them spread the area with trails and streams reinforces the goal of the creation of this water bike.

1.2 Problem Statement

In most rural areas, school students face challenges in transportation facilities. This challenge becomes more difficult when there are long distances, poor road conditions, and lack of transportation options. Although conventional bicycles are common and affordable transportation, it is limited to land travel and cannot cross bodies of water. In addition, there are water bikes designed that have the potential to cross land and water. However, the design cannot meet the needs of rural users due to its complexity and high cost. In addition, the difficulty in the mechanism for the transition between land and water modes is complicated and inefficient. This makes it unsuitable for daily use by students.

As a solution, this water bike project is carried out which aims to design and develop a practical floating system with the needs of rural students. The system will feature a foldable design during land use, while ensuring stability and buoyancy during water travel. The main focus is to facilitate the transition process between land and water modes to make water bikes user-friendly, reliable and accessible to students in rural areas.

1.3 Research Objective

There are several objectives to be achieved in this project. Objectives are important to ensure that all efforts undertaken have the desired end goal.

a) To design and analyze a water bike floating structure

b) To fabricate water bike floating structure

1.4 Scope of Research

The scope of this project is as follows:

- To sketch the raw design with different concept.
- To finalize the design according the chosen concept.
- To draw a detailed drawing using Catia V5 according the chosen concept.
- To analyze by testing the strength of the project through Catia V5 progress.
- To fabricate water bike floating structure using hollow steel .
- To fabricate water bike floating system system using PVC pipe.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In the realm of aquatic transportation, where innovation meets recreation, the water bicycle surfaces as a subject of ingenuity and sustainable mobility. This is because bicycles do stand out to be testaments of human ingenuity, keeping away from the reliance on petrol that characterizes the traditional automobile. For example, boats and jet skis, embracing the aquatic domain, do possess this special unique trait, relying on alternative means to traverse the water's expanse.

Water bicycle design and fabrication are based on various aspects, from buoyancy and stability and the choice of material. The body of research dealing with water vehicles already conducted provides insightful analysis into the consideration of engineering and design concepts applicable to this project. To further inform the design and manufacturing of these floating bicycle systems, information and ideas are gained through reviewing the literature on water bicycles and related watercraft. Therefore, before planning a water bike, materials or references are required from a wide variety of literary works are identified.

2.2 Amphibious Vehicle

Many amphibious vehicles (AVs) in use today derive from concepts from World War II (Majumder* & Chowdhury, 2021). This vehicle was once developed for military use. Now AVs have been modified for leisure and tourism. In addition, it also provides unique observation opportunities on land and underwater. Then they offer travelers fun deals to see beautiful places.

Amphibious vehicles are multipurpose means of transportation that can be used on land and in water, as well as underwater (Suraj et al., 2017). The idea behind this vehicle was sparked by observations of "amphibious" animals, such as crocodiles and frogs, which can live on land and in water. The versatility of these creatures is an inspiration for engineers who design vehicles that can move between different habitats with ease.

2.2.1 Amphibious Aircraft

Because of its unique take-off and landing system, amphibious aircraft can overcome the issue of poor airport infrastructure. Their ability to take off and land on land and water gives them greater flexibility (Liem, 2018). Furthermore, amphibious aircraft do not add to air traffic congestion because they operate at lower altitudes than normal commercial passenger and cargo flights. Therefore, it is a good choice for places with a lot of flight traffic and few airport facilities.

Figure 2.1: Amphibious aircraft (Liem, 2018)

2.2.2 Amphibious Boats

Some modern examples of amphibious boats include developments from New Zealand, the three-wheeled RIB and the Iguana Yacht. What unites these various items is an improvement in the practice of boating. Various advantages are obtained, such as easy carrying of cargo, safe boarding and landing, access to the sea from anywhere, and no need for a marina, if the boat is allowed to run on its own while simplifying and developing the yacht (Suraj et al., 2017).

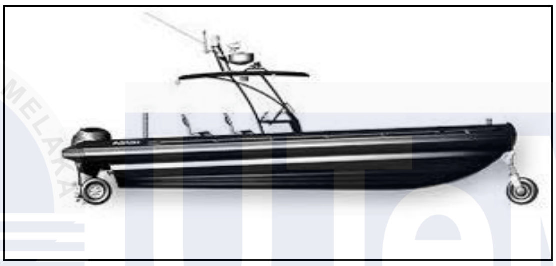

Figure 2.2: Amphibious boat (Suraj et al., 2017)

2.2.3 Amphibious Cars

The concept of an amphibious car began with the car. But their development was hugely kick-started through the Second World War. During World War II, two of the most important amphibious vehicles ever made were built. The most common was the German Schwimmwagen, a small 4x4 vehicle akin to a jeep that was developed in 1942 by the engineering company Porsche and was widely used in World War II. Erwin Komenda, the company's body building designer, took the Kübelwagen's engine and drivetrain and developed the amphibious bodywork. The Ford GPA, sometimes known as the (Seep-short for Sea jeep) was an amphibious variant of the Willys MB jeep during World War II. In the 1950s, Australian Ben Carlin drove and sailed Half-Safe with a specially modified GPS around the world (Suraj et al., 2017).

Figure 2.3: Amphibious cars (Suraj et al., 2017)

2.2.4 Amphibious Buses

Amphibious buses are employed in some locations as a tourist attraction. A recent design is the AmphiCoach GTS-1 (MGawande & Mali, 2016). These vehicles easily transition from land to water while giving visitors a thrilling opportunity to explore rivers and urban sites. Combining elements of a bus and a boat, the AmphiCoach GTS-1 demonstrates an innovation in vehicle design that ensures a safe and enjoyable journey.

Figure 2.4: Amphibious buses (MGawande & Mali, 2016)

2.2.5 Amphibious ATVs

Amphibian ATVs stand for all-terrain vehicles and are perhaps the smallest of non-air-cushioned amphibious vehicles. Quite popular earlier in North America, they remained in vogue during the early 1970s and in the 1960s. Amphibian ATVs are generally compact, lightweight, offroad vehicles with an integrated hard plastic or fiberglass body tub, six powered wheels, or occasionally eight and low-pressure balloon tires (Suraj et al., 2017).

Figure 2.5: Amphibious ATVs (Suraj et al., 2017)

2.2.6 Amphibious bicycle

Saidullah's Bicycle is one design that has presumably gotten the most attention. The bike is propelled by two blades that are fastened to the spokes and four rectangular air-filled floats for buoyancy (Awasthi, 2017). On Moraga's Cycle Amphibious, a simple tricycle frame mounts three floaters that produce the push and the flotation. The vehicle is propelled the same way a paddle wheel would be propelled by the wings on the powered wheels (Suraj et al., 2017). Even though there are still issues with cost, safety, and environmental impact, creativity and the desire for adventure are driving the development of amphibious vehicles, which holds great promise for the future of transportation.

Figure 2.6: Saidullah's amphibian bicycle (Awasthi, 2017).

2.3 Archimedes Principle

Archimedes principle relates buoyancy to displacement. That means any object, either wholly or partially immersed in a fluid, is buoyed up by a force equal to the weight of the fluid displaced by the object. The buoyant force acting on the object is going to be equated with the weight of the fluid displaced by the object (Cardoso dos Santos et al., 2007).

In terms of buoyancy, it is the force applied by a fluid, which acts to oppose an object's weight. Buoyancy force is able to hold an object on the surface of the fluid if the object is less dense than the fluid or if the object is the right shape such as a boat. However, the force acting on the object by the buoyancy force is opposite in direction with the gravitational force (Chang Chun kit, 2012).

Cohesive force acting on the surface of the liquid, according to Archimedes' principle, may affect the buoyancy of small objects or those of a particular surface character (Naylor & Tsai, 2022). This may come about even though it does not have any direct impact on surface tension. Understanding these two principles is therefore key to the appropriate prediction of how objects behave when they interact with fluids, both in scientific and technical settings.

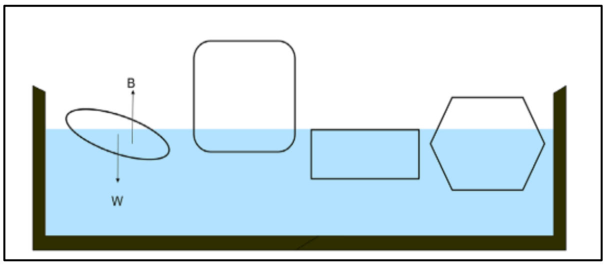

Figure 2.7: Floating objects as levers (Reich, 2023)

Gravity and buoyancy forces act together to produce a moment in the buoyancy of asymmetric bodies, or ship tilts at sea. The force grows with the tilt angle serving as a lever. To analyze ship shapes, Archimedes needed to account for the minuscule thick shapes that added up in parallel along the longitudinal dimension by applying the multiplicity principle, thus illustrating how to apply his code. In general, floating objects act as levers about their center of buoyancy. The opposing force, if they are pushed into the fluid, will depend on the force of the push as well as other objects and the fluid's characteristics (Reich, 2023).

The magnitude of buoyancy force is determined using the formula below, where $Vdisp$ is the volume of fluid that the object's body displaces, and B is the amount of buoyancy force acting on the body. ρ is the fluid's density, and g is the location's gravitational acceleration. An object's volume must be larger than the volume of the displaced fluid for it to float on the fluid's surface (Chang Chun kit, 2012).

$$\text{Fb} = \rho g V$$

2.4 Existing Product

There are already few competitive water or hydro bikes available. With a few minor variations, these bikes are all remarkably similar in size and functionality. The following list highlights the top water bikes.

2.4.1 Schiller Water Bike

With its slim form and ergonomic user interface, the Schiller Water Bike is an ideal example of hydrobike technology, which is why it leads the industry. Each of the two flotation devices attached to this bike is 12'8" in length.When the rider applies power, an attached propeller facilitates movement of the bike (Flynn et al., n.d.).

Figure 2.8: Schiller Water Bike (Flynn et al., 2022).

2.4.2 Hydro bike Explorer

Another well-liked model is the Hydro bike Explorer. This bike is constructed similarly, with a user-powered propeller and flotation devices on either side. They used 17 in. Powder-Coated Aluminum as frame and Seamless while Molded polyethylene as a hull (Chang Chun kit, 2012) . But compared to the Schiller bike, this model has a much larger and less streamlined design. For simplicity of transport, it disassembles into several parts. Additionally, the Explorer has a maximum speed of six miles per hour (Flynn et al., 2022).

Figure 2.9: Hydrobike Explorer (Flynn et al., 2022).

2.4.3 Sea Cycle SOLO

The Sea Cycle SOLO is the final competitor to be highlighted. Its dual flotation structure is like that of the previous bikes. Its seat has a lowered profile and may accommodate more passengers by adding more seats (Flynn et al., 2022).

Figure 2.10: Sea Cycle SOLO (Flynn et al., 2022).

2.4.4 Low-Cost Water Bicycles as a Means of Tourism in Banjir Kanal Semarang

The water bike that was planned for this study is 180 cm in length, 123.2 cm in width, and 90 cm in height. The floats are made of PVC tubing with a diameter of ten inches, and the structure that supports them is composed of aluminum (Ismail et al., 2022).

Figure 2.11: Banjir Kanal Samarang water bike (Ismail et al., 2022).

2.4.5 Amphibious Bicycle in India

India is facing two challenges: poverty and flooding on a regular basis. Most flood fatalities in India are also caused by poverty. So, they developed an amphibious bicycle using fabricated galvanized iron sheet (G.I.) for the floats and a straightforward frame consisting of steel rods with a 6 mm diameter to lower the frame's total weight. However, it failed when it was running in the water because the rod used in the frame had insufficient strength to withstand the forces applied to it. The result of both is the manufactured amphibian bicycle model (Awasthi, n.d.).

Figure 2.12 : Amphibious bicycle driving test on the road and inside the water (Awasthi,2017).

2.5 Fabrication Process

Fabrication refers to the process used to create a finished part or product by forming, adding or removing material from a raw or semi-finished metal workpiece.

2.5.1 Welding Process

Welding is a fabrication technique used to fuse materials together, most commonly thermoplastics or metals. Usually, to accomplish this, the workpieces are melted, and a filler material is added to create a pool of molten material, which cools to make a strong junction (John et al., 2016).

2.5.2 Grinding Process

An abrasive wheel is the cutting tool used in the grinding process, a sort of material removal technique. It uses abrasion to remove material, and it usually results in very smooth surface finishes (John et al., 2016).

2.5.3 Drilling Process

Drilling is the process of making a hole in a solid substance, like concrete, metal, or wood, with a drill bit. The bit rotates at speeds that range from hundreds to thousands of revolutions per minute while being forced up against the work piece (John et al., 2016).

2.5.4 Cutting process

A disc cutter machine is a tool that can be used to cut flat plates, bars, hollow tubes, and other materials. This machine will be required to cut the raw material to the required dimensions. It's important to measure and label the material before cutting it. The material must next be clamped onto the disc cutting machine. Make sure the material is clamped down tightly before beginning to cut it (Chang Chun kit, 2012).

2.6 Engineering Design

Engineering is a field that uses advanced technology along with a depth of scientific and mathematical understanding to solve challenging issues (Putra et al., 2023). An important component of engineering is the iterative design process, which requires the improvement of solutions. This approach delves into how to convey complex technological ideas, mathematical models and scientific principles.

The design process, in general, is a set of structured procedures that bring creative solutions to practical problems in engineering (Majumder* & Chowdhury, 2021). Design begins with ideas and brainstorming, informed by user surveys and research. The next process in conceptual design is developing rough sketches and prototypes, which lead to detailed designs using software such as CATIA V5. The design is then validated for performance and safety. Next followed by finalizing components such as weight and dimensions. Some calculations and Finite Element Analysis ensure fluid and chassis related design, while CFD analysis for aerodynamic behaviors.

Engineering design is necessary for the transformation of new concepts and established technology into high-value systems and products (Yellowley Ian, 2011). It assures that concepts are workable and efficient by using scientific and technical knowledge through prototyping and testing. Such a methodology improves functionality and efficiency through various skills.

The engineering design process helps people apply theoretical concepts to real-world problems, adding new information and abilities to mechanical engineering (Ngo, 2024). For example, Engineers keep their knowledge updated with new technologies by iterative stages of prototyping and testing, which help in creativity and efficacy in the development of mechanical solutions.

Design is an important industrial activity and affects product quality (Prasad et al., 2014). It ensures the functionality of a product that is produced. This is also to meet safety standards and regulations. Effective design increases production efficiency and can reduce costs.

2.6.1 CAD (Computer Aided Design)

This proposed CAD technique is very important in modeling and tool path planning, especially for free-form surfaces (Van Tuong et al., 2019). Advanced CAD software enables precise designs and complex geometries. CAM techniques impact and bring these models towards effective machining. This results in precision, quality and efficiency for industries such as aerospace, automotive and consumer electronics. Using advanced software for 3D modeling can reduce time and risk in design and manufacturing (Prasad et al., 2014). By simplifying the modeling process, it reduces costs and guarantees faster and higher quality output.

Dental CAD/CAM technology is used in education and daily practice for training, patient education, diagnostics and surgical simulation. It enhances dental education through hands-on digital modeling. It also improves patient care by providing clear treatment explanations and accurate diagnostics (Abdullah et al., 2018).

Virtual turning and milling simulation with CATIA V5 enables precise machining processes (Dubovska et al., 2014). Before actual production begins, engineers can find problems and improve efficiency by simulating toolpaths, modeling components and setting machining parameters. By reducing errors, this supports accurate resource planning and improves overall manufacturing quality.

2.7 Hull

A catamaran is a type of multi-hull boat that consists of two parallel hulls of the same size (Zaim Asyraaf, 2022). The catamaran's wide beam that makes a big impression on the water can provide stability. Unlike monohull boats, which rely on ballast keels for stability. Compared to monohulls, this design offers a smoother ride. This is because it can reduce heave and wave motion. The catamaran's wider stance also reduces wake formation, which increases efficiency and reduces disturbance to the surrounding water. Catamarans are well-liked for sailing, recreational boating, and even business applications because of their comfort and stability.

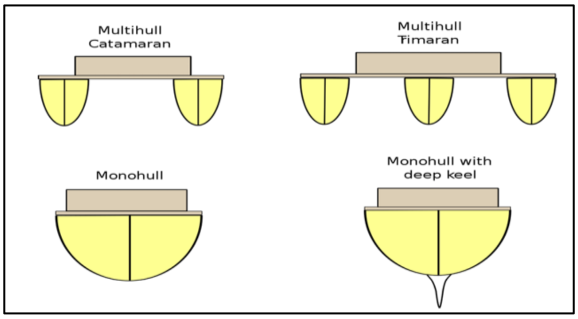

Figure 2.13: Type of hull (Zaim Asyraaf, 2022)

The hull of a wheeled amphibian is an enclosure that houses the engine compartment, cargo compartment, crew compartment and several other vehicle parts (Majumder* & Chowdhury, 2021). Because amphibious bodies have to meet certain marine design requirements, they are fundamentally different from other bodies in the military automotive assembly. Specifically, it needs to be shown so as to provide the necessary buoyancy and stability qualities. This is to create a configuration that will produce a power speed relationship to operate on water.

The shape and specifications of the bottom hull body of an amphibious hybrid vehicle are very critical in making it float. To ensure adequate buoyancy, which will keep the car afloat and stable in the water, the hull must be accurately calculated. The shape and volume of the hull, and the material composition, are important aspects in determining buoyancy because they affect its weight-carrying ability and its displacement (Majumder* & Chowdhury, 2021). When designing any form of water bike, it is important to know how to estimate the dimensions of a hull. All forces and resistances must be calculated using the exact dimensions of the hull.

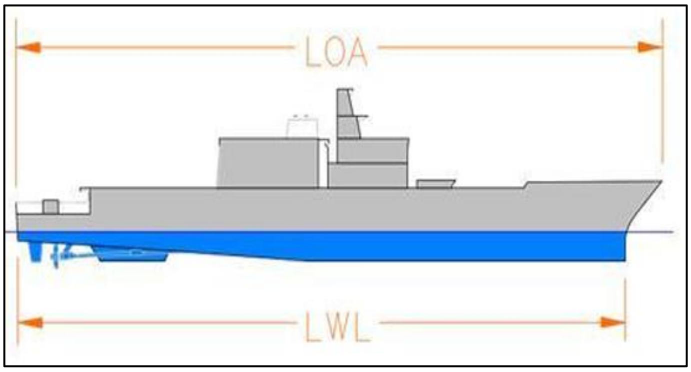

Figure 2.14: Dimension of hull for LOA and LWL (Chang Chun kit, 2012).

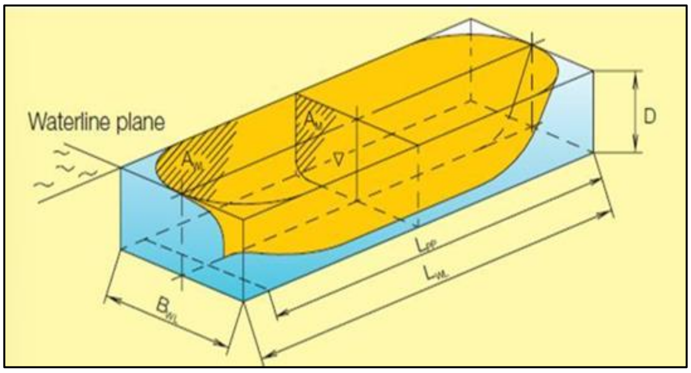

Figure 2.15: Hull dimension under waterline (Chang Chun kit, 2012)

Figures 2.14 and 2.15 illustrate the correct method for measuring a hull. The following explanation will apply to the symbol used in the figure (Chang Chun kit, 2012).

I. The extreme length from one end to the other is called length overall. LOA.

II. Waterline length (LWL) is the length, measured in profile, between the two extreme points of the waterline, fore and aft.

III. The vertical distance between the waterline and the bottom of the hull is referred to as the draft (D).

IV. The length between perpendiculars of the summer load waterline is measured from the afterpost sternpost to the intersection of the stem.

V. The greatest beam at the water line is termed beam water line (BWL).

2.8 Summary

From the review of several articles, it will assist in the study of types of materials used for frames and floats in various projects. Most earlier models of water bikes could only be used on water. They are incapable of moving on land or in water. Our project can switch from land to water without having the bike's float to be taken off.

The design process to make this water bike will also be done according to the steps that have been arranged. SolidWorks and Catia V5 are two examples of software that has been used to test the stress and deformation of materials. For this reason, Catia V5 will be used in the project's creation. Analyses from Catia V5 have been chosen to help assure that the picked material meets the durability, performance, and cost-effectiveness requirements of the project.

Some materials have been selected based on selected characteristics. The materials that have been examined for this study are frames made of galvanised iron and aluminium. While moulded polyethylene and PVC are used to make the floats. The main material for the frame structure chosen for this project is steel-based material. Therefore, ABS coated metal pipe which is a modern material will be applied in this project. While multihull catamaran will be practiced in the manufacture of floats. The material selected is PVC which has a high level of buoyancy above water. Finally, some fabrication processes will be done based on the guidelines that have been studied.

CHAPTER 3

METHODOLOGY

3.1 Introduction

A basic idea for an amphibious bicycle can be drawn up by adding attachments to a normal bicycle that facilitates smooth motion in the water and should not hinder running on land. A few design considerations should be prioritized, such as buoyancy pressures that water exerts on the body and ease of handling of attachments. This chapter will explain the created concept design to solve the problem statement. This chapter also discusses how all the concept designs were evaluated to obtain the finalized concept. Material selection and fabrication processes are also discussed in this chapter, showing how the raw material is cut and the finishing process into the desired shape design.

3.2 Flow Chart

The flow chart, as shown in Figure 3.1, indicated that research was to begin with a survey of previous journals' literature. Use this as a reference or project guide in the literature review. Then a draft of a rough design is made. A few of the concept ideas for this project have been scribbled on paper and the best ones chosen. It is the design and analysis using Catia that helps in ensuring that the final product is safe for use and that it serves the required purpose, mainly for high quality. The fabrication process then began after the purchasing of the selected component is done. The final evaluation in the testing process is carried out to end the journey of this project.

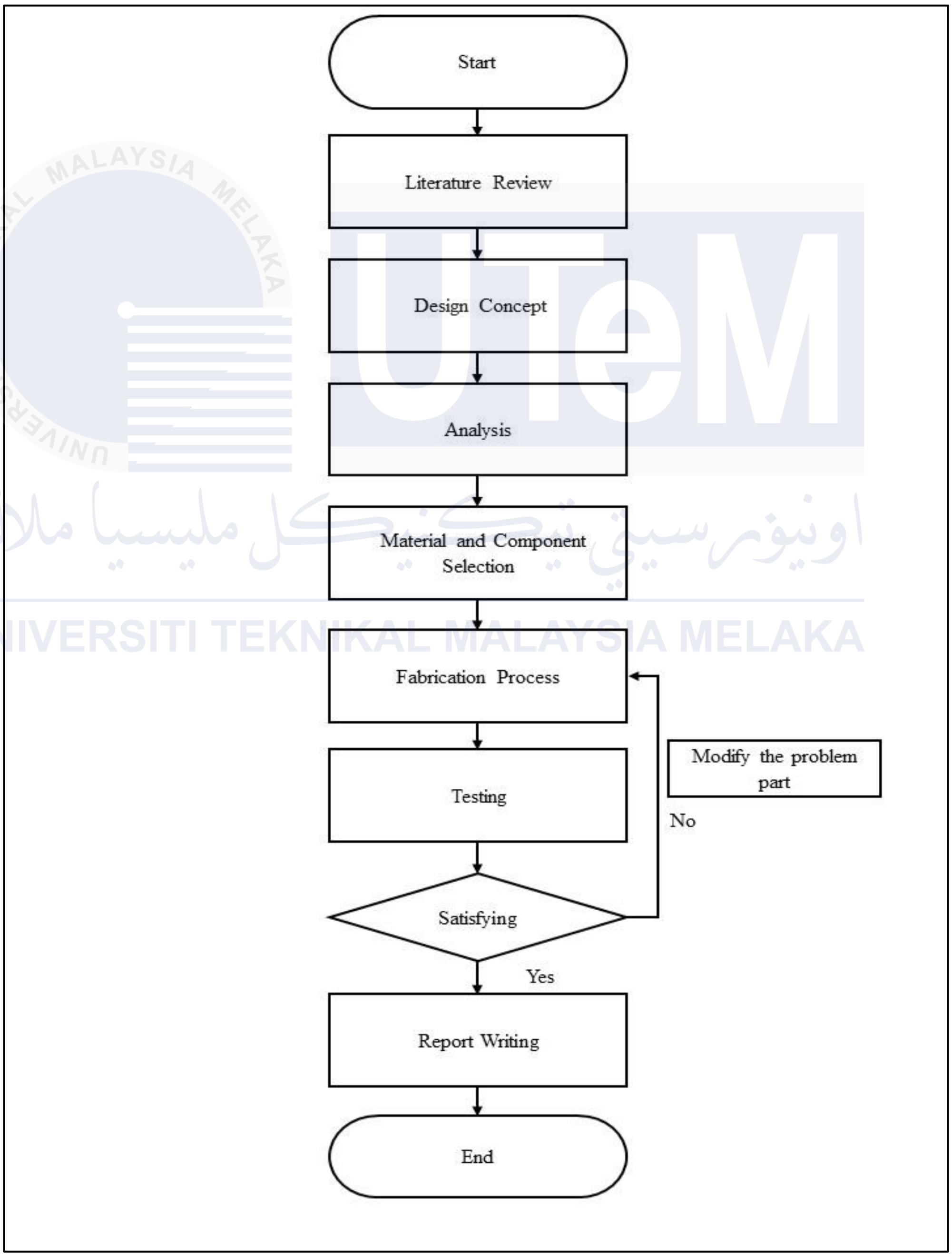

Figure 3 1: Flowchart

3.3 Raw Design Concept

In this raw concept design, some rough sketches of the float frame design will be shown. With this rough sketch, the most suitable design will be selected. The importance of raw concept design is that it allows brainstorming and investigations to produce creative and innovative ideas. It provides the basis on which detailed design is based and it provides the opportunity to explore various approaches. Working with raw concepts is cost-effective, as one can engage in extensive exploration without having to spend a lot of money. In essence, raw concept design ensures that the resulting product is structured in an appropriate manner to meet the project's goals.

3.3.1 Concept Design A

Figure 3.2 shows a frame structure that can be easily plugged in and out. The float system, using PVC, is attached at the front and rear in a V-shaped design. This design ensures stability in water and also allows application on land and in water.

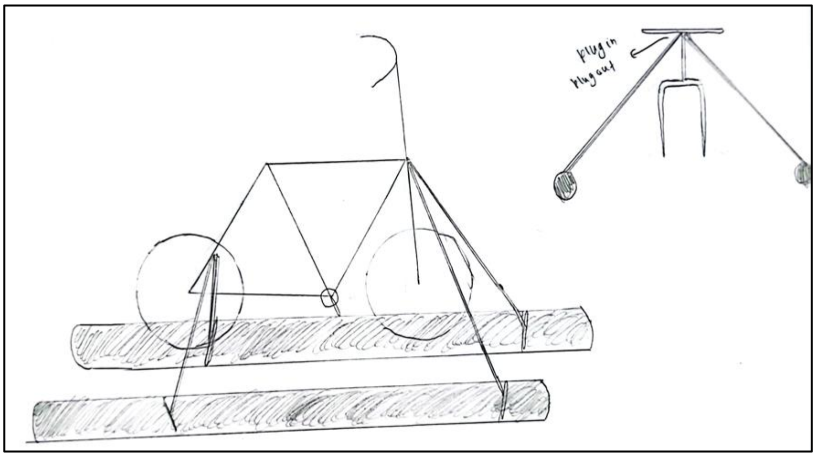

Figure 3.2: Raw design of concept A

3.3.2 Concept Design B

Figure 3.3 shows a frame structure attached at the middle and rear of the bicycle, holding PVC floats, while the front float is attached to the tire. This design may reduce stability in the water and increase the time needed to assemble all components.

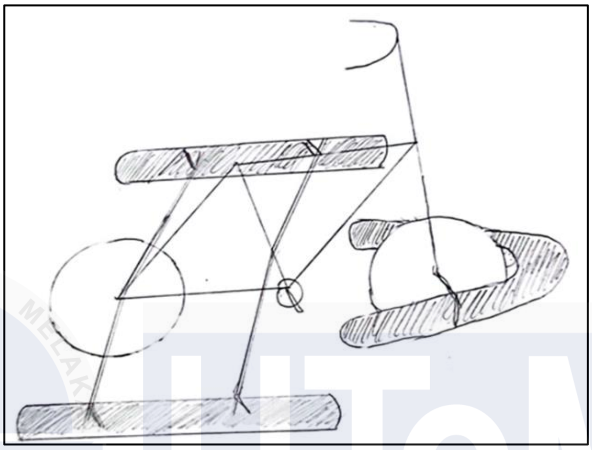

Figure 3.3: Raw design of concept B

3.3.3 Concept Design C

Figure 3.4 shows the third raw design of the frame structure angled to increase the space on the water, with floats divided into two parts at the front and rear. This design is stable but requires more time for manufacturing.

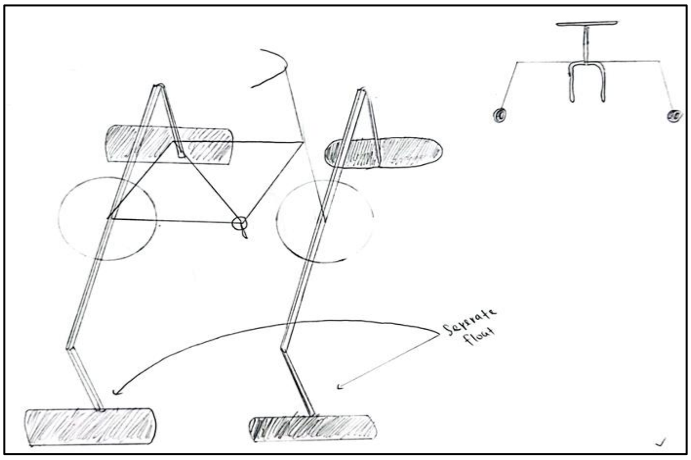

Figure 3.4: Raw design of concept C

3.3.4 Concept Design D

Figure 3.5 shows the final concept design, which is stable due to its two floats. The frame is designed to support the seat at a higher position and is foldable for use on both land and water.

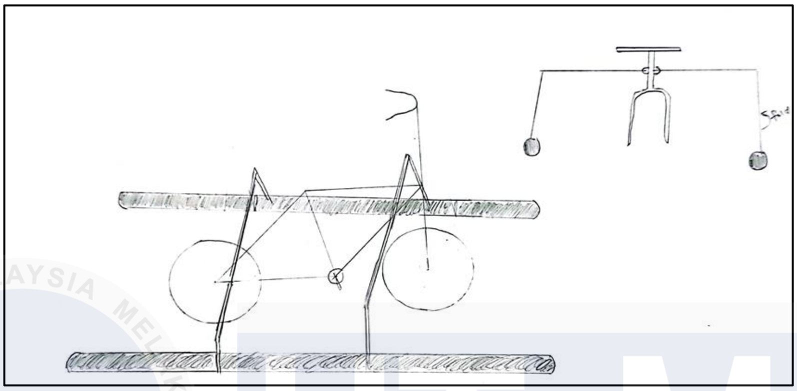

Figure 3.5: Raw design of concept D

3.4 Finalize Concept

After the four-idea design sketching, an evaluation method is utilized to develop criteria for each concept. In this section, the screening principle will be utilized. Table 3.1 identifies the process of design selection. Every concept design will be rated based on the following selection criteria such as safety, strength, stability, ease of manufacture and space optimization. From the table, we know that concept D will be chosen because it gains a high score.

Table 3.1: Design selection matrix for evaluation of best design.

Concept	Maximum Score	Criteria					Total Score	Rank
		Safe	Strength	Stability	Ease of manufacture	Space optimization		
A	10	7	7	7	7	7	35	2
B	10	5	6	6	5	6	28	4
C	10	7	6	6	5	6	30	3
D	10	8	7	8	7	7	37	1

3.5 Drawing Design by CATIA V5

Before the fabrication process is done, it is also important to make a drawing along with analysis in CAD. Catia is the software that will be used in doing this work. There are several steps that have been taken. First, the drawing process involves lines, circles, ribs, each with dimensions that have been taken from the original measurements of the bike. After that, the analysis and simulation process continue to get results. Orthography view is also important to know the view from various sides. Orthographic drawing also gives the actual dimension that has been drawn.

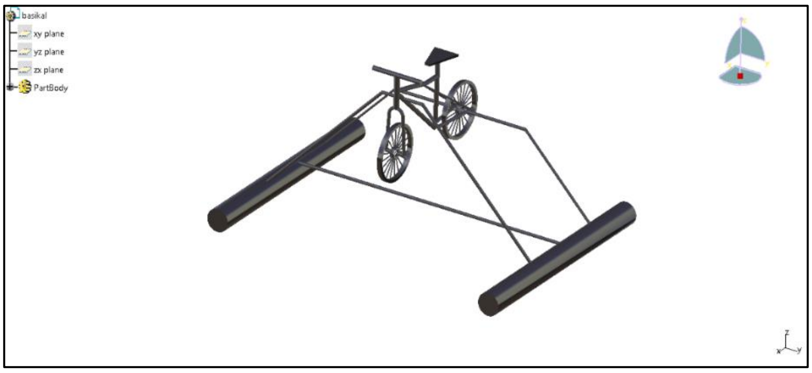

Figure 3.6: Water bike drawing by CATIA

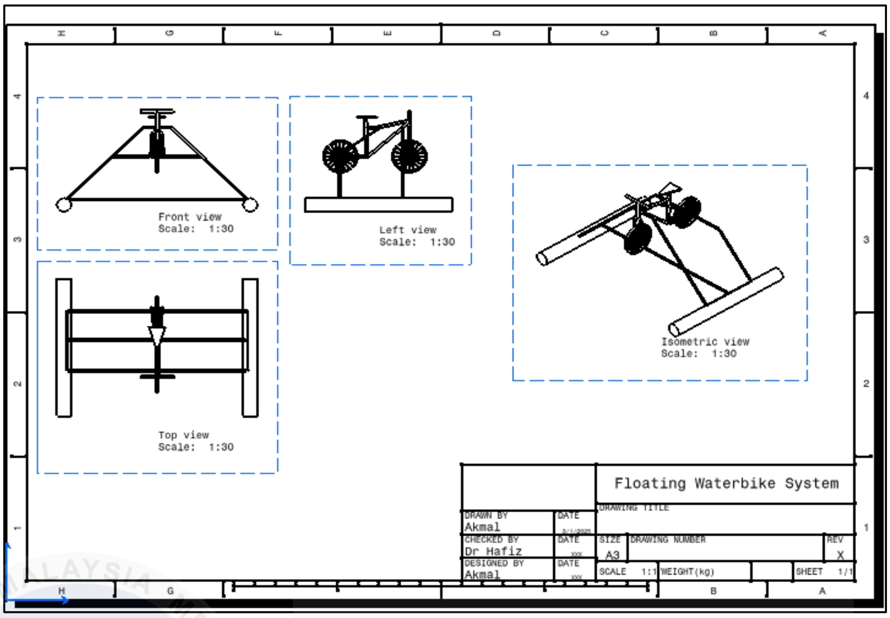

Figure 3.7: Orthographic drawing by CATIA

3.5.1 Analysis of Material Selection as Frame Structure

Figure 3.8 below demonstrates the detailed study of the distribution of stresses and shape changes in a water bike frame for different loads and materials. This visualization aids material selection and design optimization by offering important understanding about how the frame performs under different conditions. This can indicate where high-stress locations might refer to failure points, since it will show how the stress is distributed across the frame under different loads. Moreover, analysis of the deformation shall indicate how the frame deforms according to these loads, ensuring that the frame stays within reasonable bounds of structural integrity and flexibility.

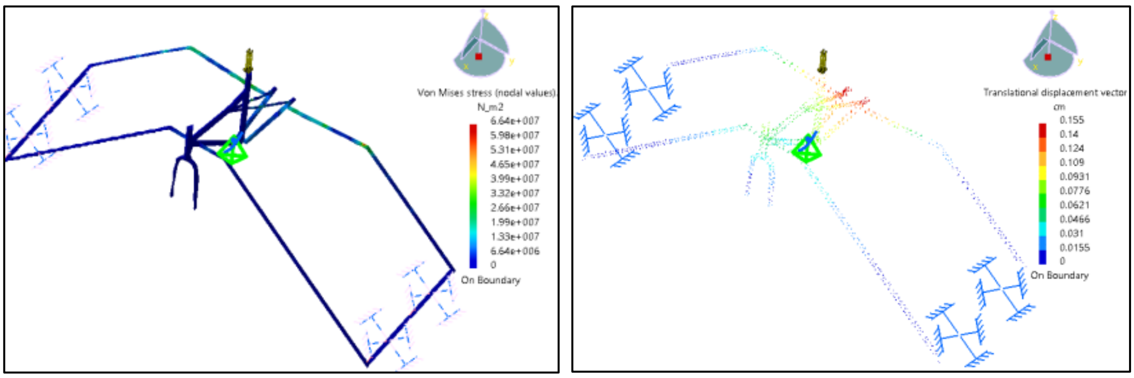

Figure 3.8: Simulation at 70kg load of Aluminum material with tension and displacement

The graph from figure 3.9 and 3.10 below is obtained from the analysis data as in the table above. Materials such as steel recorded the highest amount of von mises compared to iron and aluminum. This shows the ability of steel to withstand higher force. While for displacement, for aluminum recorded the highest value. Therefore, we find that the resistance of aluminum to deformation in terms of stiffness is lower compared to steel and iron.

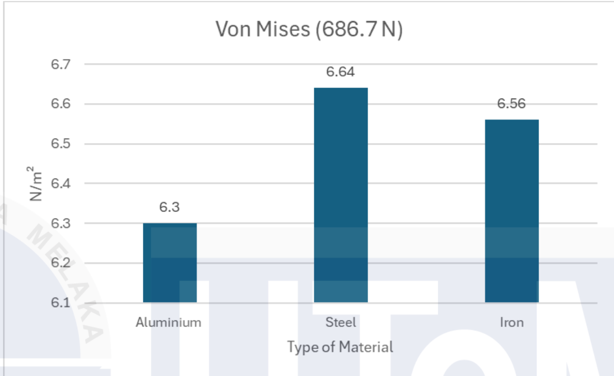

Figure 3.9: Comparison graph of Von Mises with different types of material

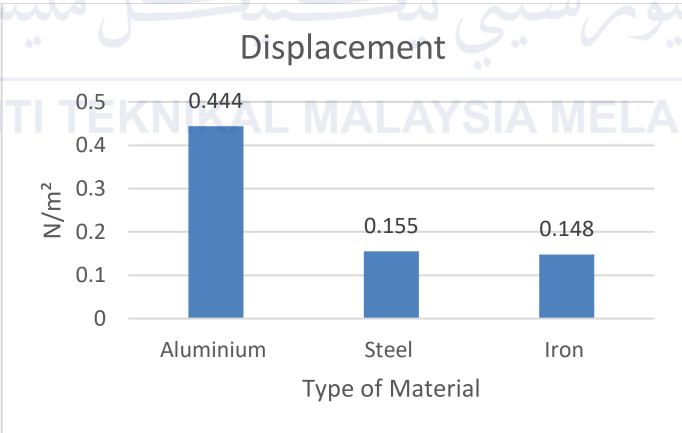

Figure 3.10: Comparison graph of Displacement with different types of material

3.6 Calculation

There are some calculations to find if a specific PVC pipe has the capability to provide the uplift needed to hold up the combined weight of a bike and rider. The buoyancy force, measured in Newtons, is the product of the fluid's density, p times the gravitational acceleration, g times the volume, V of the buoyant object. This model will help us determine the size for our float. Given the weight of the rider, weight of the bike, and a couple safety factors, we can determine how much buoyancy force we need. gravity and the density of water are relatively constant. This allows us to calculate how big a float (PVC) we need to achieve sufficient floatation (Flynn et al., 2022).

3.7 Mockup Prototype

Figure 3.11 shows that the float frame structure was made using boxes. Only one frame has been made which represents 3 structures, 2 in the front and two in the back. This mockup is done to simplify as a real picture of the project that will be made.

Figure 3.11: Mockup prototype for float frame structure.

3.8 Bill of Material

In the bill of material, there are several items that are identified and will be used in this project. This item is reviewed in the hardware store and also in the online store, Shopee.

Table 3.2: Bill of material that will be used.

No	Material	Dimension/ Weight
1	Hollow Steel	Diameter: 28mm, Length: 3000mm
2	Metal Joint	Diameter: 28mm, Length:5mm
3	Zinc Alloy Folding	Length: 80mm, Width: 30mm
4	PVC Pipe	Diameter: 254mm, Length: 2.7 m
5	Adjustable Hose Clamp	Diameter: 700mm
6	PU 301 Semi Rigid Foam	Weight: 2kg
7	Poly Saddle Fitting	Diameter: 32mm x 1 inch, 50mm x 1 inch

3.9 Total Cost

After selecting several items to use for the project, the total cost of each item is carefully recorded. Accurately kept records allow for better budgeting and cost management throughout the project.

Table 3.3: Total cost for each material

No	Material	Quantity	Unit Price RM	Total Price RM
1	Hollow Steel	5	12.35	61.75
2	Metal Joint	8	4.30 x 4 1.60 x 4	23.60
3	Zinc Alloy Folding	4	3.55	14.20
4	PVC Pipe	2	20	100.00
5	Adjustable Hose Clamp	4	2.70	10.80
6	PU 301 Semi Rigid Foam	1	65.00	65.00
7	Poly Saddle Fitting	4	12.62 x 2 14.00 x 2	53.24
	Total Cost			302.79

3.10 Fabrication Process

There are several fabrication processes that are done to complete this project. All processes have their own methods and procedures and must be followed to further launch the fabrication process. Safety precautions are important to wear personal protective equipment such as safety glasses, gloves, and other protective clothing, and that the work area should be clean and well-lit with no obstructions.

3.10.1 Cutting Process

The cutting process is done to cut the project items according to the planned diameter. Before cutting, the process of marking according to the signs that have been made delicately is done to avoid any mistakes after cutting. Next, the finishing process which is deburring on each corner and surface is done so that it is not sharp for safety purposes.

Figure 3.12: Cutting process of frame part

3.10.2 Drilling Process

Drilling is an important stage in the procedure to securely join two pieces of metal. In this operation, a hole is punched through two pieces of metal at the point where they will be connected using a drill. Hole drilling is mainly done to place fasteners such as bolts or screws that will hold the metal together to prevent movement in relation to each other.

Figure 3.13: Drilling process of fold part

3.10.3 Welding Process

For this project, welding and metal pipe connectors for safe joining of metal components are used. Welding provides a permanent connection by joining metal parts together with high heat, providing durability and structural integrity. Additionally, metal pipe connectors are used as fasteners in providing a secure yet adjustable connection, allowing flexibility in ease of assembly or disassembly if necessary. The dual approach ensures both a robust bond where needed and adaptability for parts that may require future modification or maintenance.

Figure 3.14: Welding process of plate support

3.10.4 Finishing Process

Finishing Process is the last process done in this project. This process is done to provide a beautiful surface and the desired level of functionality according to the objectives of this project. The process is to clean the surface of the bike. Sandpaper is used to rub the surface of the bike and then the bike is repainted to make this project look neat.

Figure 3.15: Repaint process to the steel surface

3.11 Summary

In smoothing this project, several processes have already been designed and carried out in an orderly manner according to the flow chart that has been planned. A project with a raw design from several concepts. The selected concepts are drawn in Catia V5 and then analyzed to determine the appropriate materials used in this project. Next, a mockup is done to give exposure to the actual project that will be done. Without exception, the calculation of the total cost is also taken seriously in this project. Finally, several manufacturing or fabrication processes are carried out to achieve the desired project.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This chapter presents the results and findings involving the developed product. This section covers the finalized product design, product specifications, working mechanism, material requirements and stress analysis. This aspect shows the level of functionality and capability of the water bike while being able to ensure compliance with performance, safety and durability standards.

4.2 Result

Figure 4.1 and 4.2 shows a design that allows for operation on land and water. The frame is constructed using strong materials such as steel providing the strength needed to support the bike and floating system. A triangular support structure is applied to the frame. This is to ensure rigidity and an even distribution of weight between the bike and the float. The floating system consists of two cylindrical floats made of PVC. It is securely attached to the frame with metal clamps and straps. To increase buoyancy and prevent water ingress, the end of the float is sealed with foam and insulating material. Overall, the prototype includes standard bicycle components such as handlebars and wheels. The design appears to be modular, facilitating easy assembly and disassembly for transportation and maintenance.

Figure 4.1: Water bike isometric view

Figure 4.2: Foldable water bike floating structure

4.2.1 Product Specifications

The water bike is built to provide great performance, reliability, and ease of use. Below are the product's specifications, which show its smart design, useful features, and high-quality standards. These details highlight our focus on meeting users’ needs and making sure the product is durable and effective.

Table 4.1: Product specification of water bike

Specifications	Results
Length(mm)	2133
Width(mm)	Fold:1100 ; Unfold:1400
Height(mm)	Fold:1100 ; Unfold:1328
Weight(kg)	35
Colour	White, blue, black
Maximum of passenger	1
Maximum Capacity(kg)	100
Material	Steel, PVC

4.2.2 Working Mechanism

Figure 4.3 shows the folding process is simple and involves three quick steps on both the left and right sides. Once the frame is folded, the bike functions as a regular bicycle that allows the rider to pedal and move efficiently on solid ground. Figure 4.4 shows the transition of the water bike to land operation, the floating system can be folded compactly. By folding the triangular frame structure inwards, the float is brought closer to the bike. Thus, it is possible to reduce its width and ensure that it does not interfere with the functioning of the bike on land.

When preparing a water bike for water operation as figure 4.5, the frame structure is laid out to use a floating system. The opening process repositions the floats outward further forming a multihull arrangement inspired by the catamaran concept. This configuration has a triangular frame structure that connects the bike to the float. The catamaran-style design ensures excellent stability on the water by evenly distributing the weight of the rider and bike on both floats.

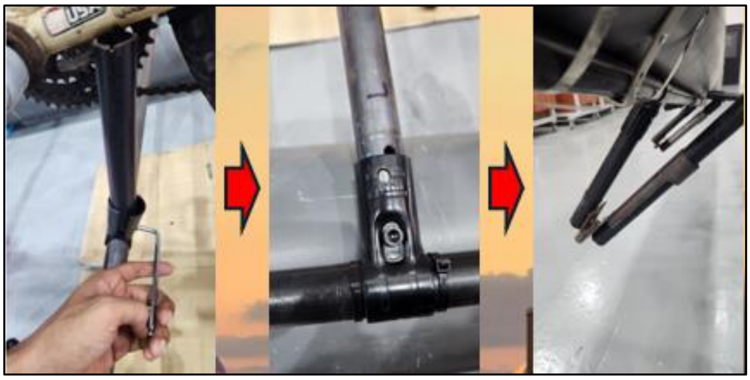

Figure 4.3: Folding process of floating structure

Figure 4.4: Water bike on land

Figure 4.5: Water bike on water

4.2.3 Strength Analysis

Table 4.2 shows that the maximum Von Mises stress of 183 MPa shown is much lower than the yield strength of steel. For mild steel with a strength of 250 MPa, the results of factor of safety (FoS) calculations show that the frame operates well within the safe stress limit. This result shows that the frame has an advantage in terms of strength.

Figure 4.6 shows a frame model that has been established and analyzed using CATIA V5 software. The connection between the components is applied using joint connectors and welding functions to ensure realistic load distribution. The objective of the analysis is to determine the maximum load that the frame can support. The frame weighs 35 kg and is designed to accommodate an average human weight of 70 kg.

Table 4.2: Result of strength analysis on Catia V5

Max Von Mises Stress	Yield Strength for steel	Safety factor (FoS)	Status
183 MPa	250 MPa	1.37	Pass

$$\text{FoS} = \frac{Yield\ Strength}{Max\ Von\ Mises} = \frac{250\ MPa}{183\ MPa} = 1.37$$

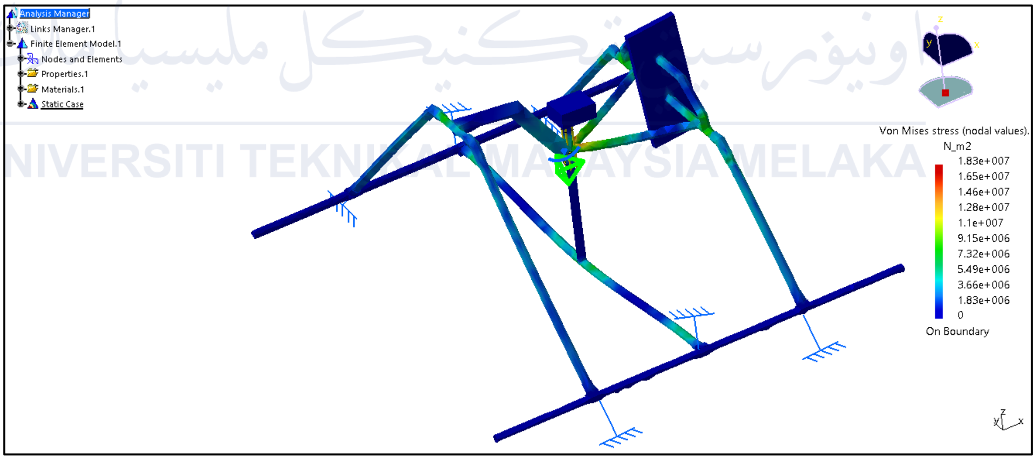

Figure 4.6: Result of strength analysis on floating frame structure

4.2.4 Buoyancy Calculation

Figure 4.7 proves that the floating testing is successful on the water with the mass of the bike and the rider. This results from the calculation of buoyancy which is proven by actual results. In addition, these results show that the buoyancy produced by the floating system is greater than the total weight of the bicycle and the rider. The engineered design also ensures stability on the water. This is in line with the product's intended function.

Required buoyancy force (Flynn et al., 2022)

Total weight = Bike Weight + Rider Weight

$= 35\ kg + 70\ kg$

$= 105\ kg$

$105\ kg \times 9.8\ m/s^2 = 1029\ N$ (Fb)

Required PVC pipe volume (Flynn et al., 2022)

Archimedes Principle, $F_b = \rho g V$

$\rho_{water} = 997\ kg/m^3$

$g = 9.8\ m/s^2$

$1029\ N = 997\ kg/m^3 \times 9.8\ m/s^2 \times V$

$V = \frac{1029}{9770.6}$

$= 0.105\ m^3$

Available PVC pipe volume (Assuming ½ of the pipe is submerged in the water) (Flynn et al., 2022)

r = 12.7 cm, 0.127m

L = 274.32 cm, 2.7432 m

$V = \frac{1}{2}(\pi r^2 L) \times 2$

$= \pi\ (0.127)^2 \times (2.7432)$

$= 0.138\ m^3$

Since $V\ available > V\ required$, big possible it will float.

Figure 4.7: Floating test on the water

4.3 Summary

Chapter 4 of the report describes the results of the water bike project focusing on its design, performance and testing. The bike is designed to work on land and water, with a steel frame for strength and PVC floats for buoyancy. It is lightweight, easy to assemble and uses standard bicycle parts.

Strength tests show the frame is strong and secure with a safety factor of 1.37. Buoyancy tests confirm the bike can float and remain stable in water, meeting all design goals. The result highlights a durable and practical bike for land and water travel.

CHAPTER 5

CONCLUSION

5.1 Conclusion

The "Design and Fabrication of Water Bike Floating Structure" project successfully achieved its objective. In the design phase, various raw concepts were developed and evaluated using a design selection matrix. The final design successfully chosen has assured stability, and the best performance. Detailed technical drawings have been produced using CAD software such as CATIA V5 allowing accurate visualization and analysis. Strength analysis under a combined bicycle and rider load of 105 kg revealed a maximum Von Mises stress of 183 MPa. This is far from the yield strength of steel of 250 MPa. Thus, this gives a safety factor of 1.37 which confirms the stability and suitability of the structure for the use of this product.

The fabrication phase involved building the frame with hollow steel and PVC pipes. This material is chosen to ensure light and effective strength and buoyancy. Installation that complies with design specifications has resulted in a practical and easy-to-operate structure. Buoyancy analysis based on the Archimedes Principle, confirms the system's ability to float. The calculated buoyancy force of 1029 N is obtained from the total weight of the bike and the rider. It requires a displacement volume of 0.105 m^3. The displacement volume of the available PVC pipe, calculated at 0.138 m^3. This has directly exceeded the requirements and has been verified through actual tests where the structure successfully floats on water.

5.2 Recommendation

To further enhance the functionality and usability of the water bike, it is recommended to replace the current PVC pipe floatation system with an alternative pontoon material. While PVC offers adequate buoyancy, it adds considerable weight to the overall system, potentially affecting ease of handling and portability. A lighter material, such as polyethylene foam or an inflatable pontoon, could provide similar or better buoyancy while reducing the total weight. This change would improve the bike's performance on land and make it more suitable for transportation in rural settings.

Future iterations of the water bike should also explore advanced materials for the frame, such as lightweight alloys or composite materials. This is to reduce weight without compromising strength. Additional user testing and feedback should guide further refinements to ensure the product fully meets the needs of its intended users.

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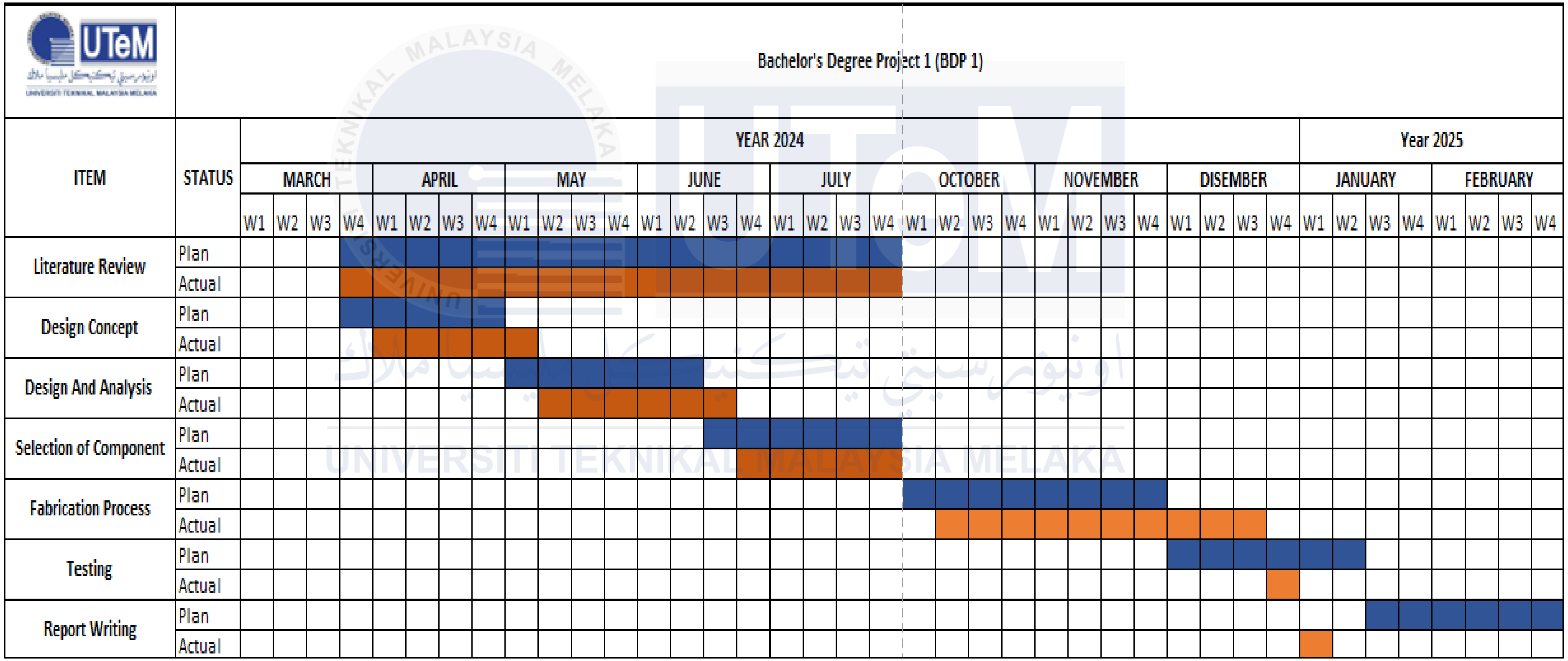
APPENDICES

Appendix A: Gantt Chart for BDP 1



Appendix B: Water bike view

Appendix C: Team member