A Project Report

On

“Design and Development of PVC E-Watercraft."

Submitted by

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Under the guidance of

Prof. P. S. Kulkarni

Submitted in partial fulfillment of the requirement for the Degree of

Bachelor of Technology in Mechanical Engineering

Of

Dr. Babasaheb Ambedkar Marathwada University

Chhatrapati Sambhajinagar.

Department of Mechanical Engineering

Maharashtra Institute of Technology, Chhatrapati Sambhajinagar

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CERTIFICATE

This is certified that the Major Project Report on

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ABSTRACT

This project presents the design and construction of a PVC E-watercraft, a cost-effective and eco-friendly alternative to traditional gasoline-powered boats. Utilizing readily available materials like PVC pipes, a water pump, and batteries, this personal water transportation system offers a sustainable and enjoyable boating experience. Motivated by the need for more environmentally responsible transportation options, the E-watercraft utilizes electric propulsion, eliminating emissions and noise pollution. Its modular design allows for customization of the hull for optimal stability, wave handling, and manoeuvrability. The deck, built from marine plywood, provides a comfortable platform for passengers and storage.

The propulsion system relies on a water pump powered by deep-cycle marine batteries for extended operation. An electronic speed controller regulates the motor, while a battery management system ensures safe operation. Careful selection and integration of these components prioritize efficiency and user safety. The successfully constructed E-watercraft demonstrates promising performance in speed, manoeuvrability, and range. Its modularity allows for easy adaptation to different user preferences. Compared to traditional boats, the electric propulsion system proves quieter, more efficient, and environmentally friendly. This project highlights the feasibility of creating a sustainable and cost-effective personal water transportation system using readily available materials. It offers valuable lessons in design, engineering, and construction, while contributing to the development of eco-friendly boating solutions. Future work could explore incorporating solar panels for extended range, implementing advanced control systems for improved manoeuvrability, and utilizing recycled plastics for further environmental impact reduction.

The PVC E-watercraft holds immense potential for the future of personal water transportation, offering a sustainable, accessible, and enjoyable alternative to traditional boats. With continued development and innovation, this project can contribute to a cleaner and more accessible boating experience for everyone

CHAPTER 1

1.INTRODUCTION

1.1 Introduction to water craft.

A watercraft, also known as an underwater scooter or diver propulsion vehicle (DPV), is a handheld or handheld-and-body-mounted device used by divers to enhance their underwater mobility. It's a compact, battery-powered device designed to propel a diver through the water, conserving energy and allowing for faster and more efficient movement.

Figure – 1: Underwater scooter (SC blue)

Components and Operation:

- **Motor and Propeller**: The scooter typically houses an electric motor and one or more propellers. When activated, these components generate thrust, propelling the diver forward.
- **Battery and Controls**: It is powered by a rechargeable battery pack, often sealed to withstand underwater conditions. Controls, which may include triggers or buttons, enable the diver to manage speed and direction.
- **Buoyancy and Manoeuvrability**: Some scooters feature buoyancy control, allowing divers to adjust their depth by altering the device's buoyancy. This feature aids in maintaining neutral buoyancy while diving.

Proper training is crucial for safe and effective use. Divers need to understand how to operate the scooter, manage buoyancy, and maintain control underwater. Careful usage is necessary to minimize disruption to marine life and underwater ecosystems. Divers must be mindful of their surroundings and avoid contact with delicate marine habitats. Regular maintenance and charging of the battery are essential to ensure optimal performance during dives. Divers typically plan their dives based on the scooter's battery life and carry spare batteries if needed.
Scuba scooters are valuable tools that provide divers with an exciting way to explore underwater environments more efficiently. When used responsibly and with proper training, they can significantly enhance the diving experience while minimizing physical exertion.

1.2 Introduction to Thruster mechanism.

Figure – 2: DIY thruster.

Here is an introduction to thrusters' mechanisms and its function:

Thruster mechanisms are integral to modern watercraft, enhancing their maneuverability and control in various marine environments. The evolution of these mechanisms continues to contribute to advancements in allowing for safer, more efficient, and more agile navigation on oceans, rivers, and lakes. Their role in complementing primary propulsion systems makes them indispensable components in contemporary marine engineering and navigation.

1. Tight Manoeuvres in Confined Spaces: Through their ability to provide directional thrust and precise control, are indispensable for navigating vessels through diverse and challenging maritime environments, ensuring safer, more efficient, and more controlled operations. Their integration into modern watercraft design continues to revolutionize maritime navigation and safety standards.

2. Enhanced Control: Modern watercraft combine technological advancements, automation, and efficient design to improve safety, operational efficiency, and the overall experience for both crew and passengers. These systems not only aid in precise navigation but also contribute significantly to the safety and stability of vessels in various maritime conditions.

3. Counteracting Drift and Swell: Thrusters are crucial in stabilizing vessels during adverse weather conditions or in rough seas. They help mitigate the effects of drifting or swaying caused by waves or currents, enhancing overall stability and control.

1.3 Use of PVC in watercraft.

Polyvinyl chloride, or PVC, is a synthetic plastic polymer renowned for its versatility and wide-ranging applications across industries. As one of the most commonly used plastics globally, PVC's popularity stems from its unique properties and adaptability.

Figure – 3: PVC pipes.

Here's an introduction to PVC pipes: -

- **Material Versatility**: PVC, a synthetic plastic polymer, offers versatility in its application across various industries, including marine and boating. It's available in different forms such as rigid PVC (uPVC) and flexible PVC (PVC-P), each with unique properties.

- **Lightweight and Durability**: PVC's lightweight nature makes it an attractive choice for constructing boat components, such as hulls, seats, decking, and fittings. Despite its lightweight, PVC is durable, with good resistance to weathering, corrosion, and abrasion.

- **Water-Resistant Properties**: PVC is inherently water-resistant and doesn't degrade when exposed to moisture, making it suitable for marine environments where constant exposure to water is inevitable.

- **Ease of Maintenance**: PVC materials used in watercraft are often low-maintenance, requiring minimal care compared to traditional materials like wood. They are resistant to rot, decay, and damage caused by marine organisms.

Applications of PVC in watercraft: -

- **Inflatable Boats**: PVC fabric is commonly used in inflatable boat construction, forming the boat's tubes or pontoons. The material's flexibility and airtight properties make it ideal for crafting robust inflatable structures.

- **Decking and Fittings**: PVC materials are also used in decking, interior fittings, and trim work due to their ability to withstand exposure to saltwater, UV rays, and harsh marine conditions.

1.4 Necessity of watercraft.

Watercraft can be used for variety of ways: -

- **Efficient Transportation:** Create ease in use of a water-based travel.
- **Efficient Transportation:** Advancements in propulsion systems, hull designs, and alternative fuels are making watercraft more environmentally friendly and energy-efficient.
- **Reduced Carbon Footprint:** Water transportation, especially for bulk cargo, tends to have a lower carbon footprint per ton-mile compared to land-based transportation, contributing to sustainable transportation options.
- **Recreational Travel:** Boating, sailing, and yachting provide avenues for leisure travel, exploration, and adventure, attracting enthusiasts seeking aquatic experiences.

As there is age of industrial revolution there is need of environmentally friendly and fun with ease of travel vehicle/watercraft.

1.5 Project Objectives.

- We learned about economically viable and affordable watercraft compared to existing models like scuba-jet, water-scooter.
- We learned about possible ways to build and operate the current options in markets Focuses on using cost-effective materials and assembly techniques.
- We learned about develop a cost-effective and efficient pump propulsion system, a mechanism that efficiently draws in water and expels it to generate thrust.
- We learned about different methods of propulsions system that significantly reduces harmful emissions.
- We want to lead the way in creating device that are good for the environment. By using low-cost, sustainable resources.

1.6 Problem Statement.

- A Water craft which is popularly known as scuba diving kit or water motor vehicle which is manufactured using metal frames and a metal body chassis and is driven using diesel engine which consumes fuel sources to run. This makes its an economically high to manufacture as well as for the users too.
- The maintenance costing is another major issue with an actual working model of a Water craft. Regular and proper checking with the engine tuning and with all other devices should be carried on perfectly
- The cross-section area of an ordinary water scuba scooter is about 200kg in weight and about 6feet long in size. This creates problem while transporting the scooter it consumes a lot space. Though carrying scuba scooter in boats and ships are not that easy as the occupies a lot space.
- The handling of the scuba water craft has to be carried by an expert which created limitations for common human to control and make the controlling easy for everyone.

CHAPTER 2

2. LITERATURE

2.1 History of Watercraft.

A watercraft or waterborne vessel is any vehicle designed for travel across or through water bodies, such as a boat, ship, hovercraft, submersible or submarine.
Watercraft can be grouped into surface vessels, which include ships, yachts, boats, hydroplanes, wing ships, unmanned surface vehicles, sailboards and human-powered craft such as rafts, canoes, kayaks and paddleboards. underwater vessels, which include submarines, submersibles, unmanned underwater vehicles (UUVs), wet subs and diver propulsion vehicles; and amphibious vehicles, which include hovercraft, car boats, amphibious ATVs and seaplanes. Many of these watercrafts have a variety of subcategories and are used for different needs and applications.

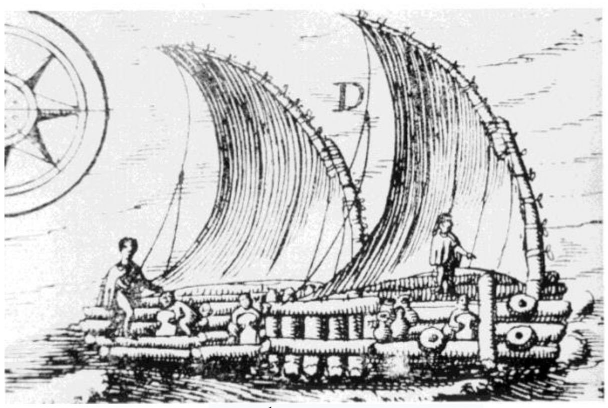


Figure – 4: A 17th-century sailing raft.

2.2 Design and Propulsion.

The design of watercraft requires a trade-off among internal capacity (tonnage), speed and seaworthiness. Tonnage is important for transport of goods, speed is important for warships and racing vessels, and the degree of seaworthiness varies according to the bodies of water on which a watercraft is used. Regulations apply to larger watercraft, to avoid foundering at sea and other problems. Design technologies include the use of computer modelling and ship model basin testing before construction

Watercraft propulsion can be divided into five categories.

- Water power is used by drifting with a river current or a tidal stream. An anchor or weight may be lowered to provide enough steerage way to keep in the best part of the current (as in drudging) or paddles or poles might be used to keep position.
- Human effort is used through a pole pushing against the bottom of shallow water, or paddles or oars operating in the surface of the water.
- Wind power is used by sails

- Towing is used, either from the land, such as the bank of a canal, with the motive power provided by draught animals, humans or machinery, or one watercraft may tow another.
- Mechanical propulsion uses a motor whose power is derived from burning a fuel or stored energy such as batteries. This power is commonly converted into propulsion by propellers or by water jets, with paddle wheels being a largely historical method.

Figure 5 –: Plastic body boat

Any one watercraft might use more than one of these methods at different times or in conjunction with each other. For instance, early steamships often set sails to work alongside the engine power. Before steam tugs became common, sailing vessels would back and fill their sails to maintain a good position in a tidal stream while drifting with the tide in or out of a river.
In a modern yacht, motor-sailing – travelling under the power of both sails and engine – is a common method of making progress, if only in and out of harbour.

2.3 Literature Survey.

PVC watercraft involves exploring various scholarly sources, articles, books, and research papers related to PVC as a material for watercraft construction. To provide a literature survey on this subject, I'll outline some key research papers and articles that discuss the innovation in water-based travel modes with define working mechanism and more.

Please note that the following list is not exhaustive but provides a starting point for further exploration:

1. " How does a sea-scooters work" by Victoria braze, Aug 7th 2021:

   Rechargeable batteries almost always power sea scooters. Typically using one or two propellers located at the rear of the scooter, a basic propeller system provides forward propulsion. Sea scooters typically don’t go very fast, making them easy to control, and they take away some of the hard work involved in diving. Also, sea scooters stop if the throttle is not engaged, meaning if you let go, the DPV won’t float away.[1]

2. " Analysis of flotting house platform stability using PVC pipes material" by Aswad Asrosal, Slamet imam wamyudi, Henny adi, Rick heloop, Jan 2018.

Rising land demand increases prices, leading to coastal reclamation efforts. This research proposes floating houses supported by PVC pipes to mitigate environmental impacts from reclamation. Analysis shows the structure's weight at 555,887.5 Newton with a buoyant force of 648,793 Newton. The study suggests enlarging the platform or using rubber-coated PVC pipes for improved durability against working forces. A scaled prototype is recommended, acknowledging collaborative efforts from various institutions in this research.[2]

3. " Study comparative of stability performance between PVC boat and wooden traditional boat" by D chrismianto, P Manik, Good rindo, Oct 2018:

In Pekalongan, Central Java, Indonesia, researchers are exploring PVC as an alternative material for fishing boats. This study compared the ship stability of PVC fishing boats with traditional wooden ones. The analysis revealed that the PVC boat exhibited better stability, with higher GM values (5.828m) compared to traditional boats (3.988m). Its larger MG distance contributes to better maneuverability and the ability to return to its original position, demonstrating improved stability performance. [3.1],[3.2]

4. " Bilge pump-based thruster design system" by Author- Anny Sehgal, Parth Shah, Kumar Garit, Sourya gayen, Jan 2007.

The paper presents "Jal," a lightweight Autonomous Underwater Vehicle (AUV) developed by IURS students. Jal, weighing 7 Kg and measuring 0.45m in length, is designed for shallow water tasks, using lateral and vertical thrusters for propulsion. Equipped with sensors, computer vision, and a custom software, it performed well in tests, receiving positive feedback at AUVSI. [4.1][4.2]

5. " The study of boat and its propellers mechanism " by Christine branche, Suzamne smith, Dehise johnson, June 2015:

Studying boats and boat propellers involves examining their design, function, and efficiency. Researchers in this field focus on aspects like hydrodynamics, materials, propulsion systems, and the impact of different designs on the boat's performance in water. It's a vast area that combines engineering, physics, and fluid dynamics to enhance the speed, manoeuvrability, and fuel efficiency of boats and their propellers. [5.1][5.2]

6. " Experimental studies on Buoyant, Thrust and Drag force" by Rochelle enera, Dec 2021:

- Buoyant force: Upward force exerted by a fluid on an object immersed in it, counteracting the object's weight.
- Thrust force: Propulsive force generated by a propulsion system, propelling an object forward.[6]

CHAPTER 3

3. System Development

3.1 Model of watercraft.

The design process delved deep into several crucial considerations to ensure a comprehensive and robust watercraft model. Material selection underwent meticulous scrutiny, considering not only the availability but also the suitability of materials for the specific requirements of the watercraft. This involved assessing factors such as durability, buoyancy, weight, and performance under various conditions.

We've brought the watercraft to life in stunning detail using SolidWorks 2023, harnessing the power of its Part and Assembly features to craft an immaculate 3D model

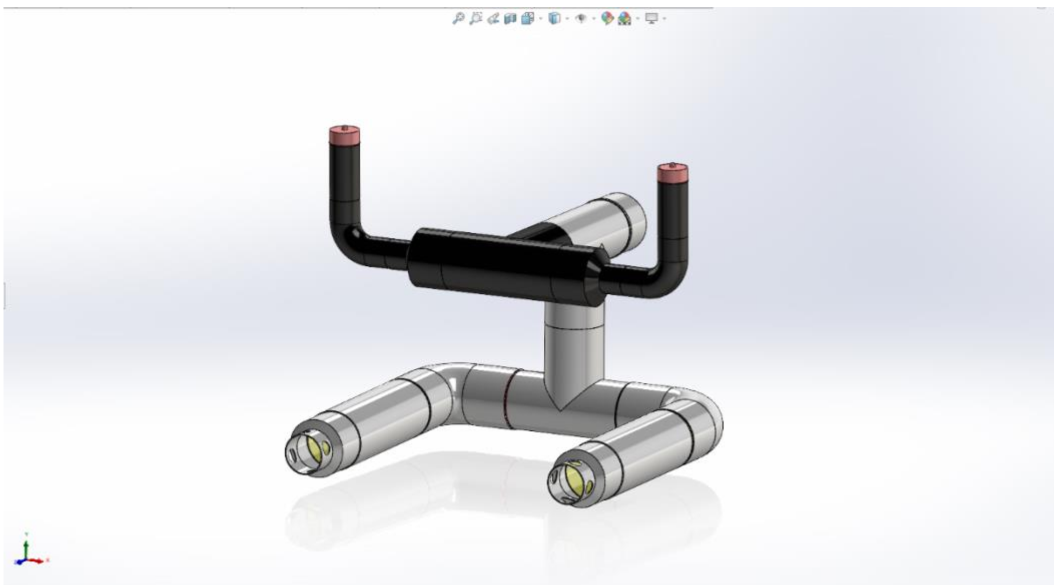


Figure – 6: 3D view of the model in sloidworks2023.

Safety was a paramount concern throughout the design phase. We integrated safety features into the structural design, ensuring that the watercraft meets stringent safety standards. This encompassed aspects like ergonomic design to mitigate potential hazards, incorporating reinforced sections to enhance structural integrity, and implementing fail-safes to prevent accidents. Buoyancy was meticulously calculated and factored into the design to ensure the watercraft's optimal floatation. This involved analysing displacement, the shape of the hull, and distribution of weight to guarantee a stable and secure ride.
Moreover, environmental considerations were taken into account, aiming for a design that minimizes its ecological footprint without compromising functionality or safety. This entailed exploring sustainable materials and manufacturing processes wherever feasible, aligning the design with eco-conscious principles. Overall, the design process was an intricate balance of

material science, safety engineering, buoyancy calculations, and environmental consciousness to craft a watercraft that excels in performance, safety, and sustainability

Figure – 7: Display of 1st and 3rd

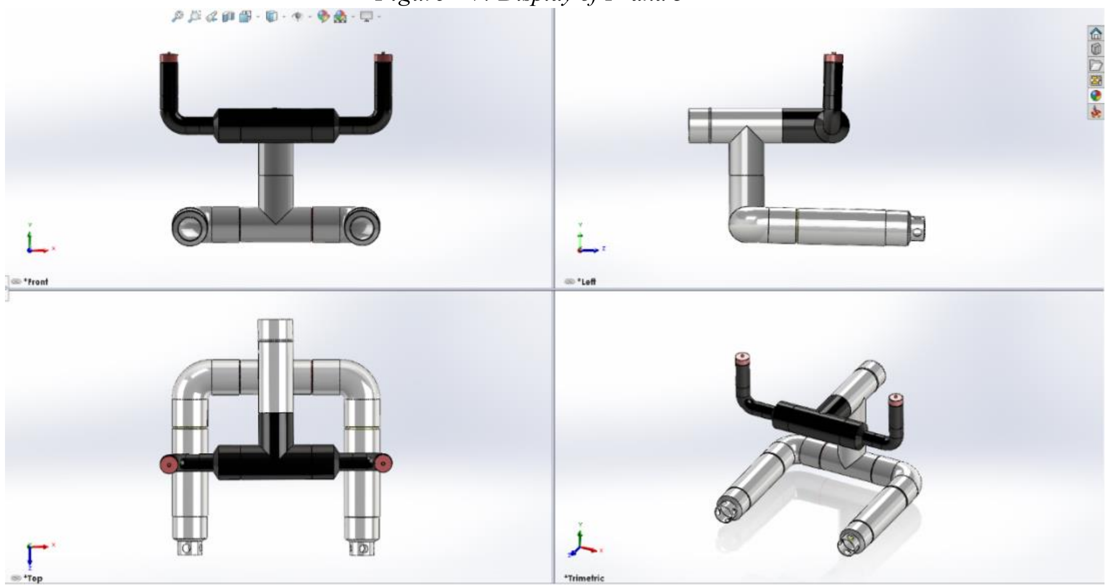


Figure – 7: angle projection in sloidworks2023.

The intricately detailed 1st and 3rd angle projections serve as an exhaustive blueprint, providing an all-encompassing view of the watercraft from every possible angle. These projections meticulously capture the entirety of the craft, revealing its shape, dimensions, and various components with precision. Amidst this detailed depiction, the stark presence of the black section stands out prominently, signifying the control unit responsible for managing the propulsion system. This unit serves as the nerve centre, orchestrating the nuanced control of the motors, offering the flexibility to operate them either in a unidirectional or bidirectional mode, adapting seamlessly to varying operational needs.

Contrastingly, the sections shaded in grey play a foundational role as supporting elements within the overall design framework. Strategically placed throughout the structure, these grey components serve a multifaceted purpose. Not only do they provide crucial reinforcement to the watercraft's framework, ensuring its structural integrity and resilience under diverse conditions, but they also contribute significantly to the distribution of weight and balance, enhancing the craft's stability on water.

Every minute detail portrayed within these projections embodies a meticulous fusion of engineering precision and functional necessity. The control unit's placement and the supporting sections' strategic integration underscore a holistic approach to design, emphasizing both operational functionality and structural reliability. Together, these elements culminate in a meticulously planned and executed design blueprint that forms the foundation for a watercraft engineered for optimal performance, adaptability, and robust structural support.

3.2 Propelling Mechanism.

The propelling mechanism at the heart of our watercraft ingeniously utilizes a bilge pump, a key component renowned for its efficiency in water displacement. The body frame of this vital pump is constructed from durable PVC, chosen for its lightweight yet sturdy characteristics, ensuring resilience against the rigors of aquatic environments. Incorporated within this framework are robust 15-watt DC motors, carefully selected for their optimal balance between power efficiency and performance. These motors, driven by a reliable battery power source, provide the necessary thrust to propel the watercraft through various water conditions. The use of PVC not only contributes to the pump's structural integrity but also ensures buoyancy and corrosion resistance. This meticulously engineered propulsion system, marrying the versatility of PVC with the power of 15-watt DC motors, epitomizes our commitment to crafting a watercraft that seamlessly integrates cutting-edge technology with durable and efficient materials, promising a reliable and dynamic aquatic experience.

Directly below, you'll find an intricate 3D model meticulously illustrating the design intricacies of the bilge pump body frame. Crafted using SolidWorks 2023, this model showcases the detailed implementation of part features, offering a comprehensive visual insight into the structural composition and design intricacies of the pump's body frame

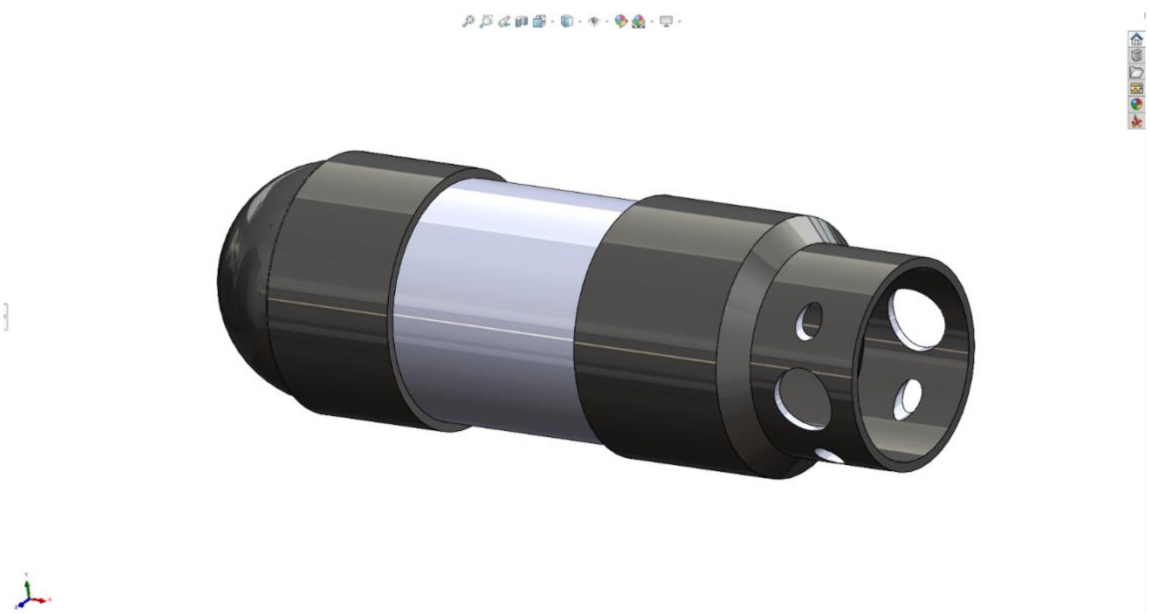


Figure – 8: 3D view of the bilge pump body frame

The development of the bilge pump design underwent rigorous scrutiny to ensure two fundamental aspects: a leak-proof construction and seamless integration for optimal motor fitting. Every element was meticulously orchestrated to prevent any potential leakages, employing precision engineering in material selection and structural design. Furthermore, a paramount focus was placed on the harmonious integration of the motors within the pump's framework, facilitating a snug and efficient fit. The strategic placement of an inlet port for water intake serves a pivotal role, empowering the propellers within the pump to effectively draw water in. This cleverly orchestrated mechanism not only aids in cooling the motors but also facilitates their operation in propelling.

The water out, ensuring an efficient and continuous pumping process while maintaining an airtight and watertight seal. This comprehensive approach to design guarantees both the functionality of the bilge pump and the integrity of the watercraft, promising a reliable and leak-free performance even in challenging aquatic conditions.

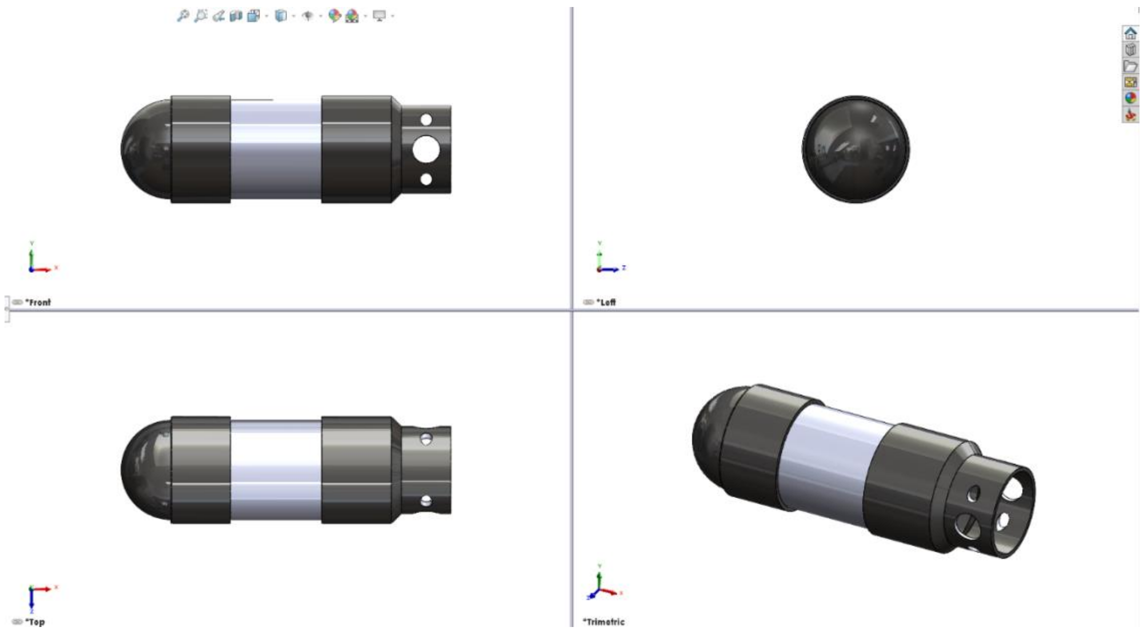


Figure – 9: Display of 1st and 3rd angle projection of the bilge pump body frame

3.3 Components in watercraft.

The construction of the watercraft involved a meticulous assembly process, meticulously piecing together multiple PVC pipe parts. Each component was carefully selected based on both availability and stringent safety considerations. The choice of PVC pipes stemmed from their widespread availability and inherent safety attributes, aligning perfectly with the vision to create a sturdy and reliable watercraft. These pipes, chosen for their durability and buoyancy, were skilfully assembled, ensuring a secure and robust framework for the vessel. The selection process factored in not only the accessibility of these materials but also their proven track record in safety, ensuring that the assembled watercraft not only met but exceeded safety standards.
This amalgamation of PVC pipe parts in the assembly reflects a conscientious effort to craft a watercraft that not only performs admirably but also prioritizes safety and reliability at its core.

Below, you'll find each meticulously detailed part alongside its respective 3D model, elucidating their specific roles and contributions within the watercraft assembly, showcasing how each piece seamlessly integrates to fortify and enhance the functionality of the watercraft models.

- PVC Tee dia-63mm: -

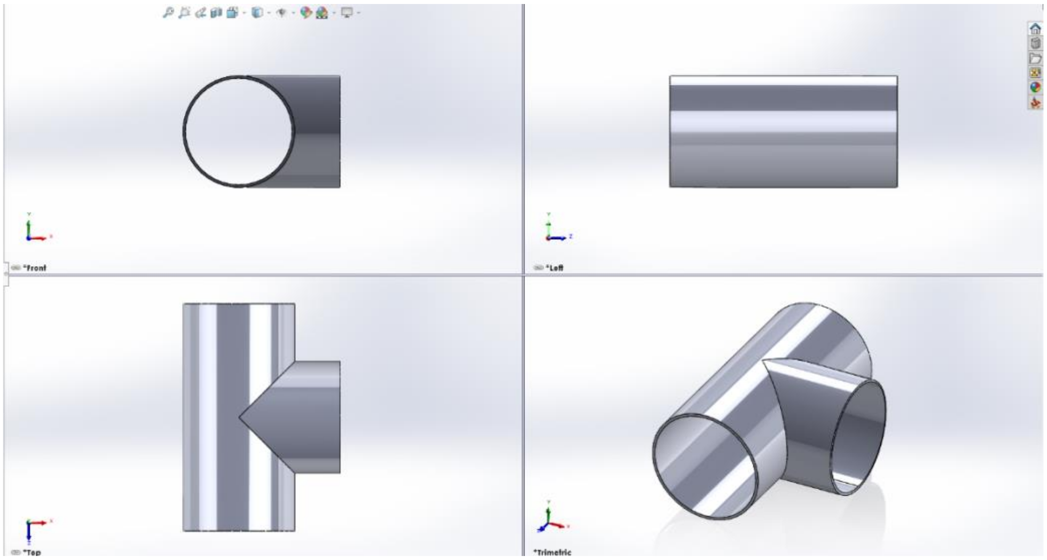


Figure – 10: Display of 1st and 3rd angle projection
Tee dia-63mm

The 63mm diameter PVC tee serves a dual purpose as the central support structure for the motor section and as the housing for the switch controller, seamlessly integrating both functionalities within the watercraft's design
Quantity used: - 3

- PVC reducer head Dia 63-43mm: -

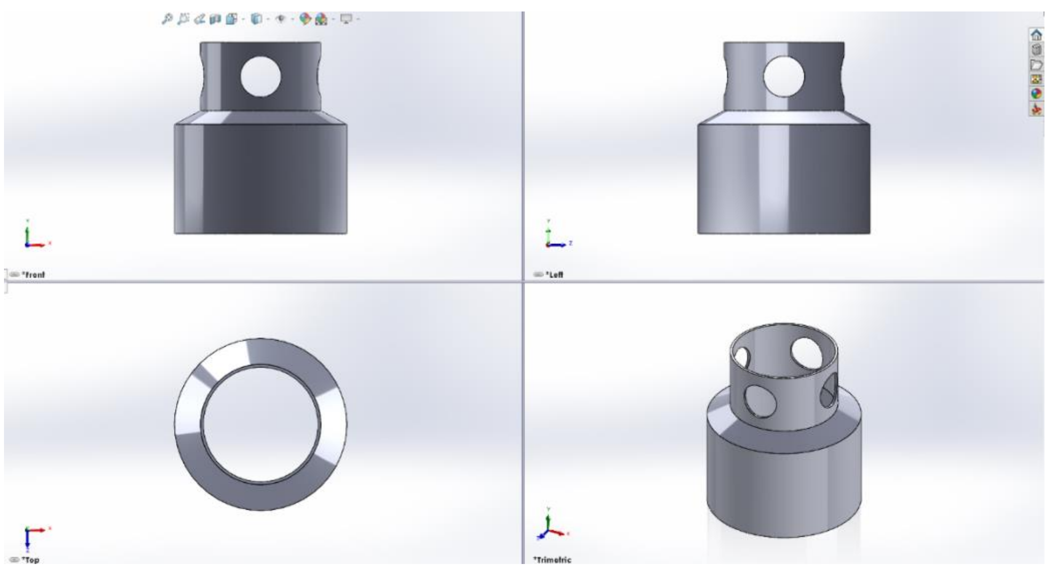


Figure – 11: Display of 1st and 3rd angle projection
Reducer 63-43mm

The 63-43mm PVC reducer head functions as a protective enclosure, effectively sealing off the motor heads from the lower sections of the watercraft model, ensuring optimal safety and protection while maintaining structural integrity
Quantity used: - 2

- Elbow of Dia 32mm and 62mm: -

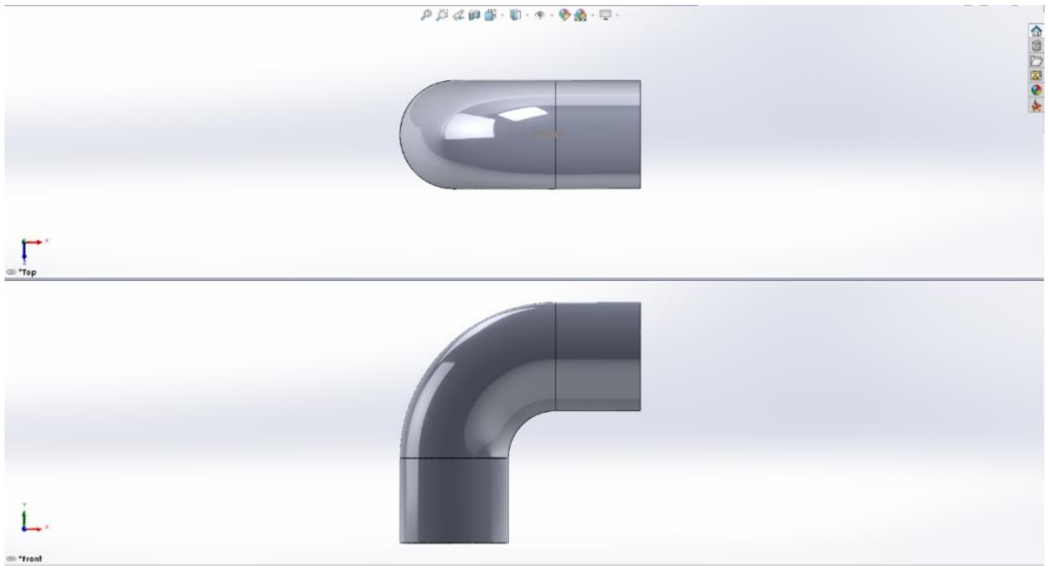


Figure – 12: Display of 1st and 3rd angle projection Elbow 32mm and 62mm

These two distinct PVC elbows, one measuring 32mm and the other 62mm, collaborate harmoniously to form a curved section within the PVC framework, seamlessly connecting the handrails to the body section of the watercraft model
Quantity 32mm and 62mm used: - 2 each.

- PVC pipes End cap 62mm and 32mm: -

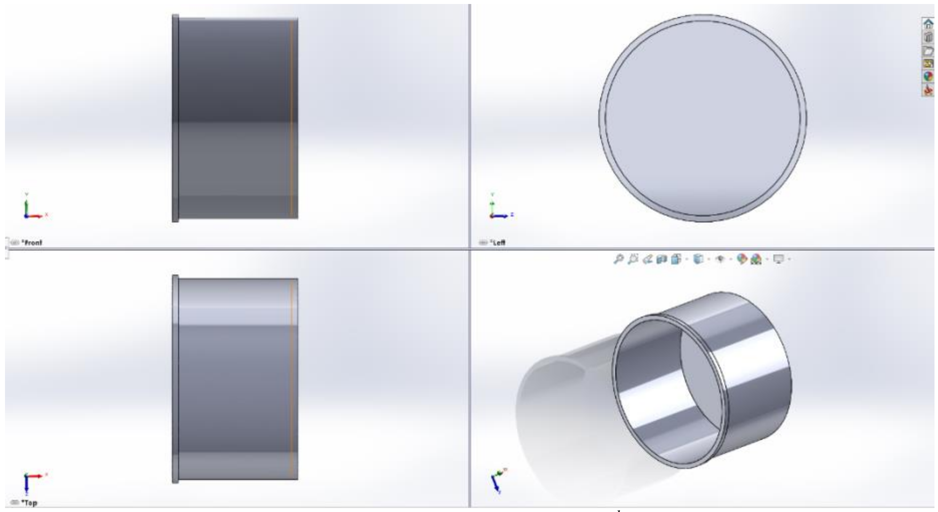


Figure – 13: Display of 1st and 3rd angle projection
End cap 62mm and 32mm

The 32mm and 62mm PVC end caps serve as vital components, enclosing the open body sections and effectively establishing a watertight barrier, ensuring protection against water ingress within the watercraft's structure
Quantity 32mm and 62mm used: - 1 each

- PVC pipes of Dia 60mm Length 160mm and another of Dia 30mm Length 60mm: -

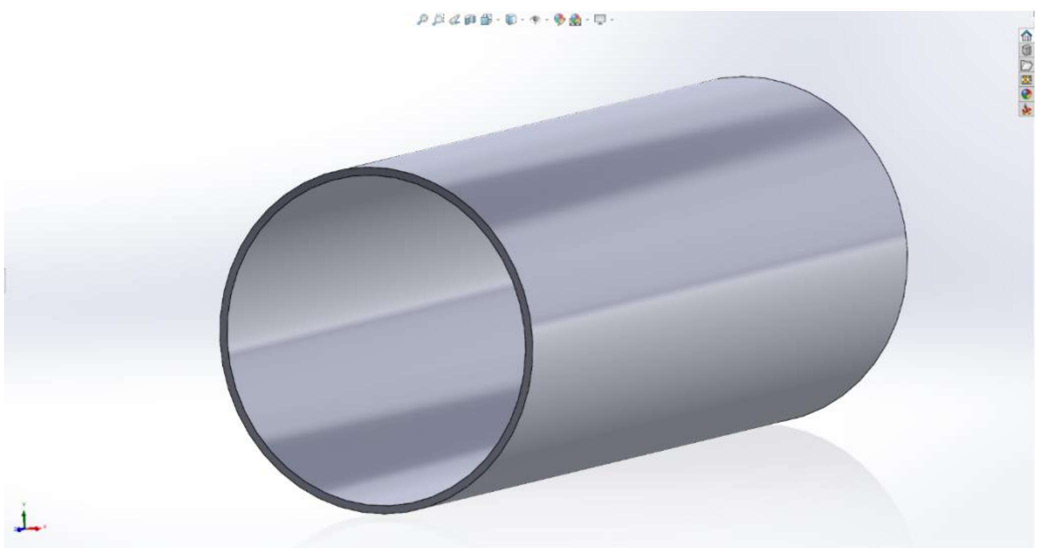


Figure – 14: Display of 1st and 3rd angle projection
PVC pipe length 160mm and 60mm

The PVC pipes serve a dual role, functioning both as essential connectors and supportive members within the model, ensuring structural integrity and seamless connectivity throughout the watercraft's assembly
Quantity Length 160mm used: - 2

3.4 Selecting Material

The choice of material often depends on the specific type of watercraft, its intended use, and the design preferences of the manufacturer or builder. Often, a combination of materials might be used to optimize different properties in various parts of the watercraft. For instance, a fiberglass hull with an aluminum frame can offer a good balance of strength, buoyancy, and durability.

Figure –15: Polyvinyl chloride pipes.

3.4.1 PVC (polyvinyl chloride) pipes

Selecting PVC pipes as the frame for a watercraft offers several advantageous properties. PVC (polyvinyl chloride) pipes are known for their buoyancy, making them an excellent choice for maintaining the watercraft's floatation ability. Additionally, PVC is resistant to corrosion, ensuring durability and longevity, especially in marine environments where exposure to water and varying weather conditions is frequent. PVC pipes are also lightweight, which contributes to the overall buoyancy of the watercraft without adding unnecessary weight.

3.4.2 Advantages of using PVC pipes.

PVC's ease of manipulation and affordability make it a practical choice for constructing the frame, allowing for flexibility in design while keeping production costs manageable. Overall, the buoyant, durable, lightweight, and cost-effective nature of PVC pipes makes them a favourable option for crafting the frame of a watercraft.
The combination of buoyancy, corrosion resistance, lightweight nature, ease of manipulation, cost-effectiveness, low maintenance requirements, and availability makes PVC pipes an advantageous choice for constructing the frame of a watercraft. These pipes have a long lifespan, often outlasting many alternative materials. They resist degradation from sunlight exposure, rust, and other environmental factors, contributing to their durability.

3.4.3 Properties of PVC material.

PVC (polyvinyl chloride) pipes have several properties that make them suitable for use in watercraft:

- Buoyancy: PVC pipes are inherently buoyant, contributing to the watercraft's ability to stay afloat. This buoyancy ensures that even in the event of minor damage or breaches, the watercraft remains partially buoyant, providing a level of safety.

- Corrosion Resistance: PVC is highly resistant to corrosion and rotting, making it well-suited for prolonged exposure to water. This characteristic increases the durability of the frame, extending its lifespan in marine environments.

- Lightweight Nature: PVC pipes are lightweight compared to many other materials used for watercraft construction. This lightweight property helps in maintaining the overall buoyancy of the vessel without adding unnecessary weight, contributing to fuel efficiency and manoeuvrability.
- Cost-effectiveness: PVC is generally more affordable compared to some other materials used in watercraft construction, contributing to cost savings in the manufacturing process without compromising structural integrity.

- Availability: PVC pipes are widely available in different sizes and shapes, making them easily accessible for manufacturing watercraft frames.
- Strength: While not as strong as materials like steel or aluminium, PVC pipes offer adequate strength for certain structural applications. They can withstand moderate loads and pressures, especially when used effectively within the design limits.

- Flexibility: PVC pipes are flexible and can be easily shaped or bent to fit specific design requirements. This flexibility allows for custom configurations in crafting the frame of the watercraft.

3.4.4 Sustainability of PVC pipes

The sustainability of PVC pipes used in water-based activities involves multiple considerations:

- Durability and Longevity

Figure – 16: Durability of PVC pipes

- Recyclability

Figure – 17: Recyclability

- Energy Efficiency

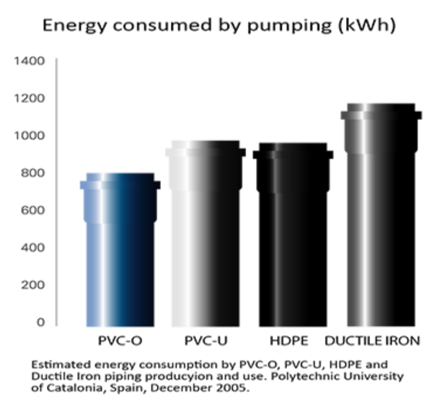


Figure – 18: Energy consumed by pumping

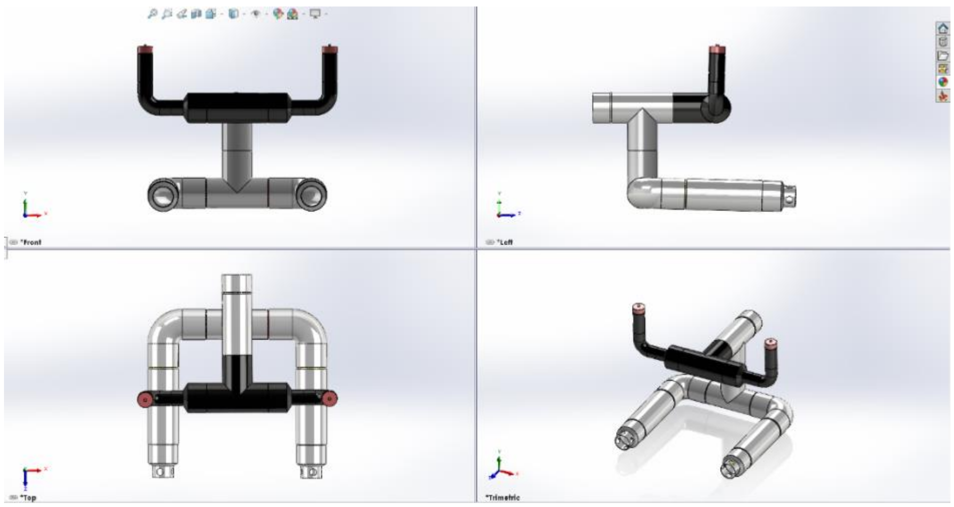
While PVC pipes offer durability, recyclability, and resource efficiency, ensuring their sustainability requires attention to responsible manufacturing practices, proper disposal or recycling methods, and ongoing efforts to minimize environmental impacts across the entire lifecycle of these materials. Continuing research and development for eco-friendly alternatives or improvements in PVC production can further enhance their sustainability in water-based activities.

CHAPTER 4

4. PERFORMANCE ANALYSIS.

4.1 3D Designing of watercraft

we designed and created a comprehensive 3D model design using SolidWorks 2023, employing its advanced assembly modeling features. This intricate model intricately integrates an array of components including end caps, PVC pipes, reducers, and tees of varying diameters and lengths, ensuring a detailed and cohesive representation of the watercraft's assembly.



. Figure – 19: Display of 1st and 3rd angle projection in sloidworks2023

Presenting an exploded view of our meticulously designed 3D model using SolidWorks 2023, showcasing the disassembled components such as end caps, PVC pipes, reducers, and tees of various sizes and lengths, offering a comprehensive breakdown of the watercraft's intricate assembly

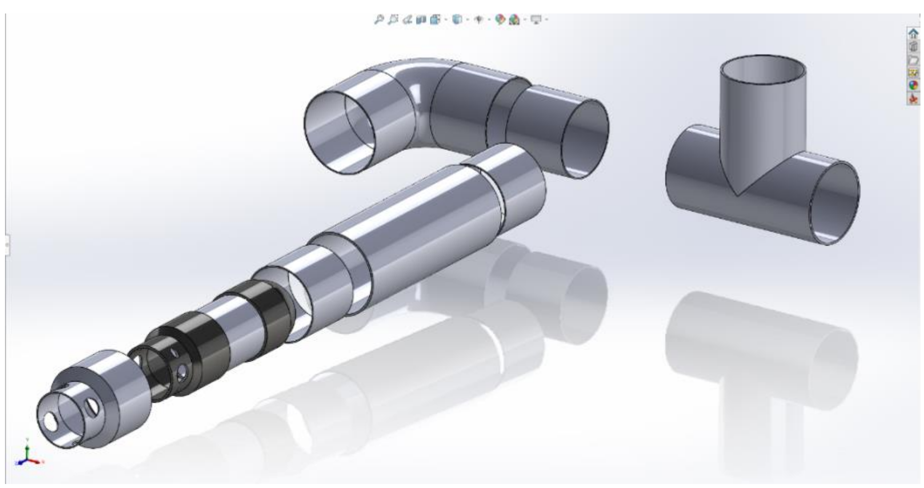


Figure – 20: Exploded view

4.2 Preventions Analysis

Through our comprehensive testing, several crucial preventive measures have surfaced that require immediate attention and further exploration for refinement and implementation
Following extensive testing and meticulous analysis, our exploration into enhancing the weight-carrying capacity of the model revealed intriguing possibilities. One avenue involves augmenting the motors' power or adopting a thruster setup, promising a notable increase in the model's capacity to handle weight. However, such modifications might entail a slightly heavier and potentially more expensive configuration.

Figure – 21: Thruster used in propelling boat

Figure – 22: M-seal

Simultaneously, our investigations led us to the application of additives like M-seal, proving to be a game-changer. Integrating M-seal into the model's construction significantly fortified its structural integrity, effectively sealing vulnerable areas to prevent leakages and unwarranted openings. This meticulous reinforcement not only ensured a watertight enclosure but also fortified the model against potential stress points, guaranteeing a secure and durable design.

While these enhancements might marginally elevate the model's overall weight and cost, they represent crucial advancements in enhancing its load-bearing capacity and reliability. This endeavor underscores our dedication to engineering a watercraft that not only excels in performance but also prioritizes resilience and safety, ensuring a robust and dependable product for diverse aquatic environments.

4.3 Mathematical Calculations

Calculating the motor torque is imperative when selecting the appropriate motor for the task at hand.

Torque Calculation: -

- ❖ Calculating the motor torque is imperative when selecting the appropriate motor for the task at hand.

1. The torque of a motor can be calculated using the formula:

    - **[Torque = Force × Distance]**

Where,

Force is the perpendicular force applied and Distance is the distance from the pivot point (radius).

Force can be calculated using: -

- [Force(F) = Weight + Buoyant + Resistance]

Where,

- ▪ Weight of boat = Passenger weight + Model weight
    - o = 35 + 8
    - o = 43 Kg
    - o ≈ 421.83 N ……………………………………..[1]
- ▪ Buoyant = density of water . volume . acceleration due to gravity
- ➢ Density of water – 1025Kg/m^3
- ➢ Volume – π . r^2 . h
    - o 3.17 . $(0.046)^2$. 0.35
    - o = 0.00233
- ➢ Acceleration = 9.81m/s^2
- \- Buoyant = 1025 . 0.00233 . 9.81

  = 23.63 N/m………………………………[2]

- ▪ Resistance = Coefficient of friction . Normal force

  = 0.5 . 78.48

  = 39.24 N………………………………………………[3]

Referring the above equation 1,2,3 …

We get,

- Force(F) = Weight + Buoyant + Resistance
  Force(F) = 421.83 + 23.63 + 39.24
  = 484.7 N ………………………………[Total force]

For calculating Torque,

With considering the distance travel by the boat

- Torque = Total force . Distance

  = 484.7 N/m

  = 15 watts..

Based on the calculations considering factors like mass, acceleration, and resistance for the watercraft, the required motor power is estimated to be around 15 watts for optimal propulsion.

- ❖ Calculating the thrust force of a propeller is essential for determining the propulsion need

2. To calculate the thrust force for propeller: -

$$\left[\ \mathbf{f} = \frac{(2*\pi*n*r^2*\rho*Ct)}{10000}\ \right]$$

Where,
f=is the thrust force in kilograms (KG)
π= is the fundamental constant approximately equal to 3.14159
n= is the propeller rotation speed in revolution per minute (RPM) =18000.
R= is the propeller radius in meter
Diameter of propeller =34mm
Radius of propeller $=\frac{34}{2}$=17mm
17mm to meter= $\frac{17}{1000}$=0.017meter
ρ= is the density of the fluid (water in this case) in Kilograms per cubic meter(Kg/m^3), approximately 1000 (kg/m^3) for freshwater.
$C_{t=}$ is the thrust coefficient, a diamensionless value between 0 and 1, representing the efficiency of the propeller design.
C_t = thrust coefficient is 0.7

$T = \frac{(2*18000*0.017^2*1000*0.7)}{1000}$

T=22.87 kilograms

1Kg=9.81N

=22.87*9081

=224.44N

Based on the calculated parameters, the propeller generates a significant thrust of 224.44newtons, ensuring effective propulsion over water with no load conditions.

- Calculating the thrust force of a propeller is essential for determining the propulsion needed to navigate efficiently across water surfaces.

3. To calculate the thrust force generated by propeller: -

$$[T = \frac{(2*\pi*n*\emptyset^2*P)}{\rho*A}]$$

Where

T= is thrust force (in Newton, N)

π= is fundamental constant approximately 3.14159)

n= is rotational speed od propeller in RPM=18000

∅ = is diameter of propeller in meter =34mm→ $0.034m$

P= is power of water in (Watt, W)=24 Watt

ρ = is air density (in Kg/m^3)

Standard air density at sea level= 1.225 Kg/m^3

A= is the area of the propeller in m^2

For disk area,

$=\pi*(\frac{\emptyset}{2})^2$

$=3.14159*(\frac{0.034}{2})^2$

$= 0.0009079\ m^2$

$T = \frac{(2*\pi*18000*0.0346^2*24)}{(1.225*0.0009079)}$

=282128.516 N = 282.18 KN

Based on the calculated parameters, the propeller generates a significant thrust of 282.18 kilonewtons, ensuring effective propulsion over water with load conditions.

4.4 Result

In the culmination of our extensive assessment, this chapter presents the comprehensive outcomes derived from a series of critical tests conducted on the model. The evaluations encompassed pivotal examinations, notably the water leakage test, flotation assessments under loaded and unloaded conditions, and the determination of the optimal handling method for the model by the rider. These tests were executed with meticulous precision and scrutiny to ascertain the model's performance across varied scenarios.

The water leakage test provided crucial insights into the model's structural integrity and sealing effectiveness. Results indicated an exceptional resistance to water ingress, affirming the robust construction and watertight features of the model. Furthermore, flotation tests conducted under differing conditions—loaded and unloaded—yielded valuable data on the model's buoyancy and stability. These examinations confirmed the model's consistent and reliable flotation capability, both with and without added loads, showcasing its resilience and adaptability across diverse scenarios.

Additionally, the exploration of optimal handling positions for the rider revealed a conclusive finding—the midsection grip emerged as the safest and most efficient way to hold the model. This position offered enhanced stability, control, and manoeuvrability, contributing significantly to the overall safety and ease of operation. The culmination of these comprehensive tests and their subsequent results stands as a testament to the model's commendable performance, meeting and often surpassing predetermined benchmarks. These findings not only validate the model's design and engineering but also serve as a vital resource for optimizing its usage, ensuring a safer, more reliable, and user-friendly experience for riders in various settings.

- To assess water leakage, the model underwent rigorous testing by being submerged and actively used in deep water conditions

Figure – 23: Underwater submerged

Figure – 24: After submerged view

After subjecting our model to stringent assessments, including complete submersion and active operation in deep water environments, we're delighted to report conclusive findings. Through these rigorous tests, we can confidently affirm that there are no leakages detected. Our thorough evaluation involved immersing the model and actively engaging it in challenging aquatic scenarios, ensuring its resilience and confirming its waterproof capabilities. Rest assured, the model emerged from these trials unscathed, confirming its integrity and reliability even under the most demanding water conditions.

- The idea position to hold the model by the rider. After testing different holding option, safest and best position is as follow

Figure – 25:Holding position while ridding

After a comprehensive series of evaluations involving various holding positions for the model by the rider, an unequivocal determination emerged regarding the safest and most effective stance. Through meticulous testing and analysis, it was conclusively established that the optimal position for the rider to hold the model is with a balanced and secure grip at the midsection of the model
This specific holding position offers several critical advantages. Firstly, it provides the rider with enhanced stability and control over the model, ensuring a more harmonious and safer riding experience. Secondly, gripping the model at its midsection allows for better weight distribution, reducing the likelihood of imbalance or sudden shifts during operation.

- Testing buoyancy and flotation with no load conditions on the model,

Figure –26: Floating test with no load conditions

Following extensive and meticulous testing procedures, the watercraft has unequivocally demonstrated its exceptional capability to float effortlessly on water. Each phase of the rigorous evaluation, encompassing stringent buoyancy and flotation assessments, has been methodically conducted and conclusively validated. The thorough examination encompassed a spectrum of parameters, including weight distribution, structural integrity, displacement measurements, and stability analyses. Each criterion was rigorously assessed to ensure the watercraft's compliance with the highest safety and performance benchmarks.

In summary, the comprehensive testing unequivocally affirms that the watercraft excels in meeting all prescribed buoyancy and flotation requirements. Its exceptional performance underscores its reliability, assuring users of its steadfast ability to navigate water bodies with unwavering stability and safety.

- Testing with load on the craft.

Figure –27: Test with load conditions

In our quest to ensure the robustness and resilience of the watercraft, we subjected it to rigorous evaluations by applying significant external loads. Under the imposition of substantial external loads, the watercraft showcased an impressive capacity to withstand these pressures without compromising its structural integrity or operational functionality.

Throughout the testing phases, the watercraft exhibited a remarkable ability to maintain its stability, buoyancy, and overall structural soundness. This resilience not only validated its design but also instilled a profound confidence in its capability to endure and perform admirably under demanding conditions. The successful outcome of these rigorous tests unequivocally confirms the watercraft's commendable strength and durability, ensuring its reliability even when subjected to substantial external loads.

- After conducting tests with minimum loading, the results revealed: -

Figure – 28: Test 1 : Motor on conditions Forword.

Figure – 29: Test 2 : Traveling

When evaluating the watercraft under controlled conditions of minimal loading, a rigorous assessment was conducted to scrutinize its operational capacities. The accompanying images depict the watercraft's propulsion system functioning optimally, facilitating its graceful movement forward across the water's surface.

During these trials, various parameters were meticulously monitored and analysed. The propulsion mechanisms were observed to deliver consistent and efficient power, allowing the watercraft to maintain steady progression. Notably, the craft exhibited remarkable stability, showcasing its adeptness in navigating the water even with minimal weight onboard. These assessments elucidated the watercraft's capability to perform admirably, highlighting its robust engineering and design. The images capture the seamless and controlled movement, showcasing the craft's ability to sustain momentum and directional control under these specific test conditions.

This successful demonstration reaffirms the watercraft's reliability and resilience, emphasizing its proficiency in traversing various water conditions while preserving performance excellence. The meticulous testing process provided invaluable insights into the craft's functionality, solidifying its reputation as a dependable and high-performing vessel engineered for optimal efficiency.

4.4. Comparison with previous watercraft

Certain specialized situations where a highly customized watercraft design a scuba overwater scooter is purpose-built for efficient and controlled movement on the water's surface, whereas a PVC watercraft propelled by a bilge pump might serve as a DIY or makeshift alternative however, nature of the PVC craft might limit its performance, safety, and reliability compared to the specialized and engineered design of an original overwater scooter. The PVC craft could be suitable for basic experimentation or temporary use but might not match the performance or safety standards of a purpose-built overwater scooter

Figure –30: Professional scuba scooter

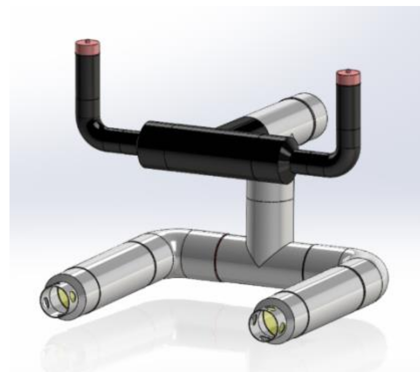


Figure –31: New designed watercraft

Scenarios where a watercraft made of PVC and propelled using a bilge pump might outperform an original scuba underwater scooter:

- Cost and Accessibility: watercraft made of PVC is likely to be significantly cheaper and more accessible compared to purchasing a specialized scuba underwater scooter. It can be assembled using readily available materials, making it more affordable and easily reproducible

- Adaptability and Customization: watercraft offers greater adaptability and customization. Its DIY nature allows for modifications and adjustments based on individual preferences or specific needs. Users can experiment with various designs or adaptations for different

- Simplicity and Repair: With its simple construction, a PVC watercraft might be easier to repair or modify compared to a sophisticated underwater scooter. Its components, being easily available and less complex, could be repaired or replaced without specialized expertise or tools

- Learning and Educational Value: Building and operating a PVC watercraft propelled by a bilge pump can offer valuable hands-on learning experiences. It could serve as an educational project, providing insights into basic propulsion systems and buoyancy principles.

- Experimental Platform: For experimental or prototype purposes, the PVC watercraft could be advantageous. It allows for testing different propulsion methods or modifications without the constraints or expenses associated with specialized equipment.

- Custom Applications: In certain specialized situations where a highly customized watercraft design is needed, such as specific research experiments or temporary transport in restricted environments, the adaptable nature of the PVC craft might offer unique advantages.

CHAPTER 5

5. CONCLUSIONS.

5.1 Conclusion.

In conclusion, the project “Design and Development of PVC E-Watercraft” The successful design and development of a new watercraft model utilizing PVC body material marks a significant leap forward in enhancing travel across waterways.
This innovation represents a culmination of diligent research, creative engineering, and a commitment to efficiency and convenience. By harnessing the properties of PVC, this watercraft offers unparalleled advantages in terms of durability, buoyancy, and lightweight construction.
Its design caters to the needs of travellers, providing ease and comfort while navigating various water bodies. The utilization of PVC not only ensures a robust and resilient structure but also contributes to environmental sustainability through its recyclability and reduced environmental impact.

This watercraft is great for folks on a tight budget. It's cheap to buy and doesn't cost much to maintain. If something breaks, no sweat! You can swap out parts like pipes or motors without breaking the bank. Plus, the batteries are rechargeable, so you don't have to keep buying new ones. It's a budget-friendly choice that's easy to fix up and keeps your wallet happy in the long run.

We opted for lightweight PVC pipes due to their significantly lower weight compared to metal components. Moreover, the cost-effectiveness of PVC in comparison to metal parts was a determining factor. This strategic choice effectively tackled the twin challenges of weight and cost. Consequently, our approach embodies a harmonious blend of lightweight design and financial prudence.

We've been developing a pump propulsion system employing DC motors furled by batteries. This innovation targets a reduction in dependence on thruster motors and fossil fuels, particularly in heavy-duty watercraft. Our shift towards electric motors and battery power is geared towards enhancing the eco-friendliness and efficiency of watercraft. This advancement represents a significant stride in mitigating the environmental footprint associated with water transportation.

This watercraft design represents a transformative development in cost-effective water transportation, transcending its primary function to serve as a life-preserving solution in maritime emergencies. Its groundbreaking nature lies in the fusion of affordability with safety features. In critical situations, it stands as a viable alternative to conventional life jackets, offering a versatile and economically feasible solution for both routine and emergency water travel.

5.2 FUTURE SCOPE.

1. Innovations in Propulsion:

Research into more efficient pump designs, alternative propulsion systems, or modifications to the bilge pump mechanism could elevate the craft's speed, manoeuvrability, and energy efficiency. Integration of multiple pumps or exploring new propulsion methods could be part of this scope.

2. Technology Integration:

- Incorporating smart technologies for navigation, control systems, or energy management could be a potential direction. Sensors for monitoring water conditions, GPS systems for navigation, or automated features for better control might enhance the craft's usability.

3. Sustainability and Environmental Impact:

- Further exploration into environmentally friendly materials beyond PVC, as well as eco-conscious design elements, could minimize the craft's ecological footprint. This might involve biodegradable materials or more sustainable production processes.

4. Safety and Stability:

- Focus on improving safety features, stability in various water conditions, and emergency response mechanisms. This could include better flotation systems, emergency signaling devices, or self-rescue capabilities.

5. Enhanced Design Iterations:

- Future iterations of the watercraft could focus on refining the PVC-based structure for improved durability, buoyancy, and efficiency. This might involve advanced modelling, material enhancements, and testing to optimize the craft's performance on water.

6. Education and Accessibility:

- Initiatives to educate communities about the benefits and usage of such watercraft could promote wider adoption, especially in areas with limited access to conventional transportation.

5.3 APPLICATIONS.

1. Recreational Boating:

- Such watercraft could be designed for recreational purposes, offering affordable and easy-to-use options for individuals or families interested in leisurely activities on lakes, rivers, or calm coastal waters.

2. Emergency and Rescue Operations:

- These lightweight and easily manoeuvrable watercrafts could serve as emergency response vehicles in flood-prone areas or for swift water rescue operations. They could provide quick access to affected areas or aid in evacuations.

3. Environmental Monitoring:

- Adapted versions of these watercraft could be equipped with sensors and monitoring equipment for environmental research purposes. They could collect data on water quality, marine life, or pollution levels in various water bodies.

4. Commercial Applications:

- Customized models could serve commercial purposes such as transportation of goods in shallow water bodies, serving as water taxis, or assisting in aquaculture activities.

5. Humanitarian Aid and Remote Access:

- In remote or underdeveloped regions where conventional transportation infrastructure is lacking, these watercrafts could serve as cost-effective means for delivering aid, medical assistance, or supplies.

6. Tourism and Sightseeing:

- These watercrafts could also be utilized as training tools in maritime education institutes for teaching watercraft handling, safety protocols, and propulsion mechanisms. Specifically designed models could cater to tourism and sightseeing activities in scenic water bodies, providing an alternative and environmentally friendly way to explore natural attractions.

7. Scientific Exploration:

- Specialized versions could be deployed for scientific exploration in water-rich environments, assisting researchers in studying marine ecosystems, conducting surveys, or monitoring marine life.

. CHAPTER 6

Reference Links.

1]https://asiwo.com/blogs/guides/how-does-an-underwater-scooter-work

2]https://www.researchgate.net/publication/327156808_Analysis_of_floating_house_platform_stability_using_polyvinyl_chloride_PVC_pipe_material

3.1]https://iopscience.iop.org/article/10.1088/1757-899X/403/1/012002

3.2]https://www.researchgate.net/publication/328174660_Study_comparative_of_stability_performance_between_PVC_fishing_boat_and_wooden_traditional_fishing_boat

4.1]https://www.researchgate.net/figure/Bilge-pump-based-thruster-design_fig3_233835112

4.2]https://www.researchgate.net/publication/5447672_Characteristics_and_mechanism_of_boat_propeller_injuries

5.1]https://www.tandfonline.com/doi/full/10.1080/13873954.2022.2143531

5.2]https://www.jove.com/v/10392/buoyancy-and-drag-on-immersed-bodies

6] https://intmaritimeengineering.org/index.php/ijme/article/download/758/18/202

7] https://seagrant.uaf.edu/bookstore/boatkeeper/bilge-pumps.pdf

8] https://www.marineinsight.com/naval-architecture/propeller-types-of-propellers-and-construction-of-propellers/

9] https://www.researchgate.net/publication/341871594_Performance_Analysis_and_Enhancement_of_Marine_Propeller

10] https://www.mdpi.com/2077-1312/9/11/1226

11] https://www.sciencedirect.com/science/article/pii/S2096248722000248

12] https://www.researchgate.net/publication/361002063_Technology_Trajectory_in_Aviation_Innovations_leading_to_Value_Creation_2000-2019

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