Fabrication of Amphibian Bike (Aqua D Moto)

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Abstract

Amphibian bikes, viable both on land as well as water, currently available in the market are unaffordable to common man owing to its high cost. Therefore, the objective of the study was to develop an efficient prototype of an amphibian bike at a low cost. Before starting the design, Four Concept Models based on the principle of water bodies were developed and one Concept was finalized through Decision Matrix. Various parts such as float, paddle, and rudder were specifically designed and fabricated as per this Concept Model. An attachable and detachable structure was developed for supporting the float, and this structure was designed to be compatible with any standard bike. Structural Analysis was conducted to certify the load withstanding capacity of the bike. The developed bike completed its trial run successfully on both land and water. Safety of its amphibian traits were ensured through Stability Test. Performance of the developed amphibian bike was satisfactorily analyzed pertaining to fuel efficiency, stability, and power. This project can be developed aesthetically to play a key role in making amphibian mode of transportation affordable and universal.

Keywords: Float, Paddle Wheel, Rudder, Fabrication Processes, Test Drives

I. INTRODUCTION

Vehicle design is one of the most important factors influencing the performance of a vehicle. When the vehicle crosses a medium at a high speed, the medium may apply its resistance on the vehicle. In this project, we are planning to make an Amphibious Vehicle which can be used on land as well as water. Since this is an Amphibious Vehicle, water and air are the mediums that will provide resistance against the speed of this vehicle. The design of the vehicle should be visually attractive to people in terms of creativity and aesthetical value. Selection of the basic raw materials for the manufacture of the vehicle should ensure durability and the quality performance of the vehicle. Since the vehicle is amphibious, the basic raw materials used must be water resistant. Usually in normal manual Amphibious Bikes, a pedal drive is used to run the bike on water but in this ambient bike a 4 stroke 100 cc engine is used. In water, the paddle rotation is used to drive the vehicle and in land it is driven in the wheels. Using an engine of good efficiency, instead of pedal for manual work, can assure better performance on both mediums, with comparatively greater speed than a manual amphibious bike. The amphibious vehicles available these days are quite expensive, which makes it difficult to afford for an ordinary person. So, our aim is to create a cost-effective Amphibious Vehicle with all the safety features, good performance, and stunning appearance. Modeling was done using SOLID WORKS software. Design is to be done with the aid of some mathematical formulas. After the fabrication different experimental tests are to be done.

II. OBJECTIVES

- To develop prototype of an amphibious bike which can be used both in land as well as water
- To design a suitable detachable attachment to convert any normal bike into an amphibian
- To fabricate this attachment to suit any normal motor bike
- To determine safety, stability and efficiency of this prototype
III. METHODOLOGY

- To transform a normal bike into water movable form, a suitable attachment needs to be designed and fabricated. This needs to be affordable and reliable as well.
- From literature review carried out by going through related papers, journals and other publishing, it was discerned that existing Amphibian Vehicles are very expensive due to the high cost of the components, especially the float. Study was also conducted about water bodies and propelling devices used in the amphibian bikes.
- After the study was complete, Concept Models need to be drafted. The Concept Models mainly focus on the float and its arrangement. Among the drafted Concept Models, a suitable Model has to be selected using Decision Matrix as selection criteria. After the finalized Concept Model is identified, the next step is to Design the required parts.
- In order to design the required parts, again using decision matrix as selection criteria, suitable materials for the desired parts needs to be chosen first. Next, Design Calculations should be done to identify the dimension of all the required parts. Designed parts then have to be modeled according to these dimensions utilizing apt software.
- Then the designed parts have to be fabricated as per the model. To avoid loss of material and time, suitable fabrication process is utilized for fabrication of these designed parts. The fabricated parts are then to be assembled on the bike and test-drives has to be conducted. Finally, performance of the bike needs to be analyzed pertaining to its efficiency, safety and load withstanding capacity.

IV. DESIGN OF AN AMPHIBIAN BIKE

Design is an important task in this project. This chapter mainly deals about the design of the various parts of the amphibian vehicles like float, rudder, and propeller wheel etc.

A. Design Calculation for Float

Pipe Φ 0.219 m * 2.43 m class B
- Diameter of pipe=8” (inch) =0.219 m
- Density of water =1000 kg/m³
- Density of pipe =510kg/m³
- Volume of pipe=0.0151m³

Weight of pipe = Weight density of PVC pipe * Volume of pipe = 510 * 9.81 * 0.0151 = +75.92 N (acting downward +ve)
Displaced water =volume of pipe x weight density of water = - 897.42 N (Acting upward -ve)
Upward force = Weight of pipe + Displaced water = 75.92 + (- 897.42) = - 821.5 N (acting up –ve)

Applied load=200 * 9.81= 1962 N
Selected Factor of safety is 2
Allowable load= F.S * Applied load =2x1962 =3924 N
Number of 2.43 meter pipe required= 3924/ 821.5 =4.01(Approx 4 numbers)
Mass of pipe =No. pipes  Mass of =4 * 7.74 =30.96 kg
Φ 0.219 m * 2.43 m PVC pipe of 4 numbers are selected for making floats.

<table>
<thead>
<tr>
<th>Material</th>
<th>Mass(Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bike</td>
<td>100</td>
</tr>
<tr>
<td>Rider</td>
<td>75</td>
</tr>
<tr>
<td>Frame</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
</tr>
</tbody>
</table>

Fig. 1: Drawing of PVC pipes (in mm)
B. Design of Structure

Height of the seat from ground level (h) = 740 mm
Center Distance between two floats (CD) = 1252 mm

![Diagram represents essential clearance for frame and float (mm)](image)

Clearance between ground and float = 136 mm
Width of bike = 175 mm

![Diagram represents a right triangle](image)

\[ AC = \sqrt{(AB^2 + BC^2)} = \sqrt{(408^2 + 538^2)} = 675.20 \text{ mm} \]

Design the frame, according to its space requirement.
The frame must be lies on the dimensions
Height of frame = 408 mm
Bottom length of the frame = 1290 mm
Bottom width = 1252 mm
Top width = 175 mm

![Drawing of the frame](image)

C. Design calculation of rudder

Diameter of the rim = 230 mm
Width of the rim = 55 mm
Depth of immersion in water = 150 mm
According to its space requirement the rudders have a diameter (D) of 230 mm.
Thickness of rudder plate = 2 mm
Material: mild steel cold rolled flat sheet plate of 2 mm selected for fabrication.

**D. Design calculation of paddle wheel**

Diameter of the wheel = 580 mm
Width of the wheel = 75 mm

Clearance between wheel and mud guard = 100 mm
Clearance between wheel and chain = 20 mm
Width of the flat belt = 75 mm
Thickness of the flat belt = 5 mm
According to its space requirement, the paddle wheel outer diameter should not be more than 680 and width not more than 95 mm.

For submerged blades, spacing between blades equal to the depth of immersion.

Depth of immersion = 215 mm

Spacing between the blades should be some convenient number times pi (π)" to get the working circumference.

Working circumference = \( \pi * (680-215) = 675 \pi =2119 \) mm

Spacing between blades should not less than 215 mm

Number of blades on paddle wheel =2119/215=9.8(-10 numbers)

Most efficient energy transfer occurs when the wheel speed is between 67% and 90%.

\[
\text{Height of the blade (h)} = \frac{\text{maximum diameter of the paddle wheel}}{\text{diameter of the wheel} + 2 \times \text{thickness of belt}} = \frac{680-(580+2*5)}{2} = 45 \text{ mm}
\]

Fig 9 shows the required dimension of the paddle wheel which has 10 numbers of blades and 45 mm blade thickness. It will give thrust to propellers the vehicle.

V. MODELLING AND FABRICATION

Models of major and auxiliary parts are included. Modeled parts are then fabricated. Float.
Float is the major part of the amphibian bike. It provides the vehicle and rider to float on the water. All other parts are supported on the float. The major parts of float are: PVC pipes, Metallic frame, Top cover, Front cover, caster wheels.

- **Frame**: Frame is made of mild steel tube and angles. Top of the frame is fixed on the bike and bottom is fixed on the float assembly. The weight of rider and bike are transferred through frame to the float when the bike is on water.
- **Propeller Wheel**: It is used to create a forward thrust on water. It is provided with blades which help to carry away the water and move the vehicle forward. A synthetic flat belt is used to make the propeller and is rigidly attached to the outer surface of the wheel.
- **Rudder**: The main purpose of rudder is to steer the vehicle on water. It is made of MS plate which is fixed on the front wheel. The rudder plate’s diameter is equal to the diameter of rim. The rudder is provided with a particular thickness otherwise it will bend.
- **Water Pocket**: To prevent the entry of water inside the silencer. It is an extension of silencer with the help of MS tubes.
- **Paddle**: In case of emergency situations paddles are provided to paddle towards the shore.
- **Back Wheel Cover**: Due to the rotation of propeller wheel there is a chance of water going into the air filter and rider’s side which affects the smooth operation of the vehicle. So there is a need of back wheel cover which avoids the above mentioned problem.

![Amphibian bike on water](image1)

**VI. TESTING OF AMPHIBIAN BIKE**

### A. Stability Test

Stability of the vehicle in water is an important safety measure in the design of the vehicle for the safety of the user. The vehicle was consciously designed to maximize stability by minimizing the overall height. It is expected that the vehicle is more stable in the pitch degree of freedom than the roll degree of freedom. Design and placement of the flotation pipes that is longer than they are wide. Stability test conducted involved the rider leaving the seated position in order to stand at each corner and side of the vehicle and observe at what point the water reached the top of the flotation.

The measuring device was comprised of a measuring stick with a pin through the top, allowing a protractor to rotate about the center of the vehicle. If the measuring stick were tilted, the protractor would pivot so as to remain horizontal and by marking 90° on the stick, allowing the angle of tilt to be measured. The front and back heel angles for a single rider were found to be 2.5° and 22°. The side angle for a single rider found to be 30°.

![Stability testing & Stability test setup](image2)
1) Pitching Stability Calculation (Front Side)

Weight moved across the vessel \((w_1) = 60 \text{ kg} = 588.6 \text{ N}\)

Over all Weight of vehicle including \(w_1\) \((W) = 275 \text{ kg} = 2697.75 \text{ N}\)

Distance moved by \(w_1\) \((x) = 1467.5 \text{ mm}\)

Angle obtained \((\theta) = 15^\circ\)

GM= Meta centric height,

\[
GM = \frac{(w_1 \cdot x)}{(W \cdot \tan \theta)}
\]

\[
GM = \frac{(588.6 \cdot 1467.5)}{(2697.75 \cdot \tan 15)} = 1195.13 \text{ mm}
\]

Distance between center of gravity and bottom \((AG) = 684 \text{ mm}\)

Weight density of water = \(9810 \text{ N/m}^3 = 9.81 \times 10^6 \text{ N/mm}^3\)

Moment of inertia \((I) = M.O.I \text{ of bike about } Y-Y \text{ axis} = 35\% \text{ of } (1/12) \cdot 2430 \cdot 1770^3 = 3.93 \times 10^{11} \text{ mm}^4\)

Volume of bike in water \((V) = \frac{\text{weight of bike}}{\text{weight density of water}} = \frac{2109.15 \text{ N}}{9810 \times 10^{-6} \text{ N/mm}^3} = 2.15 \times 10^8 \text{ mm}^3\)

Meta centric height

\[
GM = \left(\frac{1}{V}\right) - \text{BG}
\]

\[
\text{BG} = \left(\frac{1}{V}\right) - \text{GM} = \left(\frac{3.93 \times 10^{11}}{2.15 \times 10^8}\right) - 1195.13 = 632.78 \text{ mm}
\]

Meta-center (M) is above the centre of gravity (G) Thus the PVC pipe is in stable Equilibrium

<table>
<thead>
<tr>
<th>Stability results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pitching stability</strong></td>
</tr>
<tr>
<td><strong>Angle (degree)</strong></td>
</tr>
<tr>
<td>Front</td>
</tr>
<tr>
<td>Back</td>
</tr>
</tbody>
</table>
### B. Performance test

1) *Fuel Economy Test*

Fuel economy test is conducted on both land and water with the help of a calibrated bottle attachment.

#### a) Procedure

- The fuel (petrol) is filled on the bottle.
- The bottle have readings
- A hose is connected on the bottle.
- The other end of hose is connected to the carburetor.
- To check the distance travelled 100 ml of fuel consumption on both land and water.
- Speedometer gives direct distance travel on land.
- In water GPS systems are used to check distance travelled.

1 Knot (NM) = 1.852 km

#### Table 3 - Fuel economy test results

<table>
<thead>
<tr>
<th></th>
<th>100 ml. Fuel consumption</th>
<th>1000 ml. Fuel consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>On land</td>
<td>4</td>
<td>40</td>
</tr>
<tr>
<td>On water</td>
<td>1.5</td>
<td>15</td>
</tr>
</tbody>
</table>

Fuel efficiency test is conducted on both land and water. The test shows high fuel efficiency on land due to the low density of air. The high density of water makes more resistance than air.

2) *Efficiency Test*

Indicate power=7.5 kW  
Speed = 7500 rpm  
Torque=7.5 Nm

**Break power**

\[
\text{Break power} = \frac{2\pi NT}{60000}
\]

**Break power**

\[
\text{Break power} = \frac{2\pi \times 7500 \times 7.5}{60000} = 5.58 \text{ kW}
\]

Frictional power=\(IP-BP=5.7-5.58=1.92\text{KW}\)

Mechanical efficiency= \((BP/IP) \times 100 = 56\%\)

Calorific value of petrol=48000 kJ/kg

#### a) On Land

Time taken for consuming 5 ml petrol=15 sec

Density of petrol=750 kg/m³

Volume of petrol consume=5 ml=5 \times 10^{-6} m³

Mass of fuel =density x volume =750x5 \times 10^{-6} =3.75 \times 10^{-3} kg

Mass of fuel consume= \(\frac{3.75 \times 10^{-3}}{15} = 2.5 \times 10^{-4} \text{ kg/sec}\)

\[
\text{Break Thermal efficiency (on land)} = \left( \frac{\text{mass of fuel consume} \times \text{calorific value of fuel}}{\text{mass of fuel}} \right) = \frac{5.58}{(2.5 \times 10^{-4} \times 48000)} = 0.465 = 46.5\%
\]

#### b) On Water

Time taken for consuming 5 ml petrol=5 sec

Mass of fuel consume= \(\frac{3.75 \times 10^{-3}}{155} = 7.5 \times 10^{-4} \text{ kg/sec}\)

\[
\text{Break Thermal efficiency (on water)} = \left( \frac{\text{mass of fuel consume} \times \text{calorific value of fuel}}{\text{mass of fuel}} \right) = \frac{5.58}{(7.5 \times 10^{-4} \times 48000)} = 0.155 =15.5\%
\]

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VII. Test Results

A. Structural Analysis Results

![Structural analysis result]

The above figure shows the analysis result, i.e., Von Mises Stress and Resultant Displacement Analysis. Through these tests, the structure is at safe. This is due to the higher value of FOS.

<table>
<thead>
<tr>
<th>Resultant displacement</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Von Mises Stress</td>
<td>0.0006 N/mm²</td>
<td>322.33 N/mm²</td>
</tr>
<tr>
<td>Resultant Displacement</td>
<td>0 mm</td>
<td>20.5656 mm</td>
</tr>
</tbody>
</table>

B. Stability Test Results

![Stability result]

The above graph shows the stability test results. i.e., pitch stability and rolling stability tests results. Through these tests, the amphibian bike is at stable equilibrium when it is in water. This is due to the higher Meta-Center among the center of gravity. If the Meta-centric height is increases the stability also increases. So, here a higher Meta-Centric Height is selected.

C. Fuel Economy Test Result

![Fuel economy graph]

The above graph shows fuel economy test results. i.e., fuel economy when it is in water and on land. Through these tests, the amphibian bike is at efficient fuel economy when it is in water compared to on land.
Fuel Efficiency test is conducted on both land and water. The test shows high fuel efficiency on land due to the low density of air. The high density of water makes more resistance than air.

**D. Performance Test Result**

![Performance curve](image)

Performance test of Amphibian bike conducted on both land and water. The test shows that the break thermal and mechanical efficiency are first increases and then decreases in a particular point. Break thermal efficiency of land is higher than that of water. The high density of water consumes more fuel.

**VIII. Conclusion**

Prototype of an amphibious bike which can be used both in land as well as water was successfully developed using low cost material with high durability. Safety was ensured through Stability Test, efficiency was calculated through Performance Analysis meanwhile, Structural Analysis certified load withstanding capacity of the design.

As the preliminary step of design, a suitable Concept Model was drafted. Subsequently highly durable materials of low cost were chosen. Then Design Calculations were utilized to identify the dimension of the required parts. Such designed parts were modelled according to these dimensions using ‘SOLID WORKS’ software.

The strength of the structure was analyzed using ‘SOLID WORKS’ software to confirm the load withstanding capacity of the prototype.

Designed parts were fabricated according to the identified dimensions to suit any normal motor bike. These fabricated parts were assembled on the prototype successfully. These parts are simple, weightless and easy to assemble and dismantle with little time and effort.

Then Stability Test was conducted with the help of analytical and experimental methods, which came back positive, ensuring safety of the prototype. Consequently, test-drives conducted on the prototype, which were also successful.

Performance Analysis of the prototype was carried out on both land and water. Naturally, efficiency of the prototype is comparatively low in water, as high density of water consumes more fuel. Meanwhile, Fuel Economy Test conducted on the prototype shows a fuel economy of 40 km/liter in land and 15 km/liter in water.

**A. Future Works**

The future works that could be conducted on this project topic are
- The present model can be modified with help of proper optimization methods.
- Filling suitable low density gas in the PVC float will reduce the weight
- In Propeller wheels (paddle wheels), using curved water buckets instead of flat blades will increase the thrust produce
- Replacing Rudder cover with low weight material (like fiber sheets, plastic sheets etc) in place of Mild Steel could increase the efficiency
- All frames can be coated with anti-corrosive paint to reduce corrosion (Zinc coating)
- Scope for developing a suitable mechanism for efficient breaking
- PVC float can be replaced with suitable lightweight, low cost fiber mold
- Mild steel frames can be replaced with suitable material carrying high weight-to-strength ratio. For example titanium, carbon fiber, aluminium alloys etc.
- Designing a suitable linkage mechanism to fix the attachment with the bike permanently will reduce the time taken for assembly and dismantling.
APPENDIX-1 BUDGETS

Table - 5
Budget of the prototype Amphibian Vehicle

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>List of Parts</th>
<th>No of Parts</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bike</td>
<td>1</td>
<td>25000</td>
</tr>
<tr>
<td>2</td>
<td>Frame</td>
<td>1</td>
<td>5000</td>
</tr>
<tr>
<td>3</td>
<td>Float</td>
<td>2</td>
<td>10000</td>
</tr>
<tr>
<td>4</td>
<td>Paddle</td>
<td>1</td>
<td>3000</td>
</tr>
<tr>
<td>5</td>
<td>Hard wares</td>
<td>-</td>
<td>2000</td>
</tr>
<tr>
<td>6</td>
<td>Paint</td>
<td>-</td>
<td>3000</td>
</tr>
<tr>
<td>7</td>
<td>Transport</td>
<td>-</td>
<td>5000</td>
</tr>
<tr>
<td>8</td>
<td>Manual labor</td>
<td>-</td>
<td>7000</td>
</tr>
<tr>
<td>9</td>
<td>Shop hour</td>
<td>-</td>
<td>5000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>65000</td>
</tr>
</tbody>
</table>

Table - 6
Budget of the Amphibian Vehicle built in the market

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>List of Parts</th>
<th>No of Parts</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bike</td>
<td>1</td>
<td>5000</td>
</tr>
<tr>
<td>2</td>
<td>Frame</td>
<td>1</td>
<td>2000</td>
</tr>
<tr>
<td>3</td>
<td>Float</td>
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<td>4</td>
<td>Paddle</td>
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<td>5</td>
<td>Hard wares</td>
<td>-</td>
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<td>6</td>
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<td>9</td>
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<td>-</td>
<td>500</td>
</tr>
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<td>10</td>
<td>profit</td>
<td>-</td>
<td>4000</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20000</td>
</tr>
</tbody>
</table>

APPENDIX-2: EXPLODED VIEW OF AMPHIBIAN BIKE

Fig. 19: Exploded View of Amphibian Bike
APPENDIX-3: NEWS ARTICLES

A. 2017 April 10 Monday

![Image](http://www.thehindu.com/news/cities/Thiruvananthapuram/an-amphibian-of-a-motorcycle/article17899345.ece)


B. 2017 April 18 City Kaumudi

![Image](http://www.ijste.org)
C. 2017 April 9 Sunday

http://www.mathrubhumi.com/thiruvananthapuram/malayalam-news/chirayinkeezhu-1.1855710

D. Monday, 10 April, 6.44 P.M

Fig. 23: Monday, 10 April, 6.44 P.M
ACKNOWLEDGEMENT

We are grateful to the Almighty for His grace.
We wish to express our profound gratitude to our guide Mr. Varma Prasad V.M, Assistant Professor, Department of Mechanical Engineering, for the selection of topic, invaluable guidance, encouragement and whole hearted help during the course of our project work.

We would like to sincerely thank Head of the Mechanical Engineering Department, Prof. Shanavas S, for all the guidance and instructions through various phases of the study.

We are obliged to all faculties in the Department of Mechanical Engineering in Musulial College of Engineering.

We also express our sincere gratefulness to Mr. Ranju R, Project Coordinator, Dept. of Mechanical Engineering, for the invaluable suggestions and motivation in completing this project work.

We express our indebtedness to the authors of the journals and articles, which are freely referred in the course of this project work.

We also thank our family and friends for their help and motivation.

REFERENCES