DESIGN OF AMPHIBIAN VEHICLE

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Abstract : Amphibious vehicle, vehicle for transporting passengers and cargo that can operate on land and in water. Amphibious vehicles include amphibious bicycles, ATVs, cars, buses, trucks, military vehicles, boats and hovercraft. It has a wide range of application in different fields. The main aim of this project is to design it efficiently for rescue purposes. This paper focuses on the concept of Amphibious vehicle which is to be designed. The designing process includes various steps. Designing is first and crucial step in fabrication of vehicle. Designing consist of rough ideas, parameters, selection of material and cad model to work on. The further process is preceded by analyzing the model.

Keywords : All Terrain Vehicle (ATV),Cad model, Parameters, Rough Idea, Selection of material

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I. INTRODUCTION

An amphibian vehicle can operate on both terrain i.e. land and water bodies as well. In this paper we will try to elaborate idea of designing an amphibian vehicle by considering various problems that will arise during designing the vehicle. Designing must be proceeding as per various affecting factors on vehicle. Even aesthesis play a crucial role in designing as the vehicle should be attractive to look. Designing has to deal with an important factor i.e. cost, design should be functional as well as cost effective, by using maximum standard parts that are available in market to make the design cost effective. To make vehicle functional, some parts must be manufactured as per the requirement. The design is kept simple and effective without increasing the unnecessary complexity. Designing gives a theoretical idea of forces acting on it and as per them we can select the material to use.

II. PROBLEM STATEMENT

Vehicle serves the purpose of transporting from one location to another. Many times we have to travel through water bodies too, at such times a boat serves as the most efficient option available. However many a times boats are not always available. At such times we have to find boats or some public ferry. This wastes time as well as money. Thus it is necessary to find a way at such situations. To eliminate all this problems and to provide people comfort of moving around anytime even in water bodies, Amphibian Vehicle was invented. An Amphibian Vehicle can travel through both land as well as water. To design the parts and select the materials as per the requirements through the process of defining the concept and brainstorming it, discussing the possible outcomes on it and deciding the efficient way to proceed, presenting the idea to the team and discussing with everyone, after that calculations are made and surveying the market for getting the most suitable parts and material for project as per the calculations.

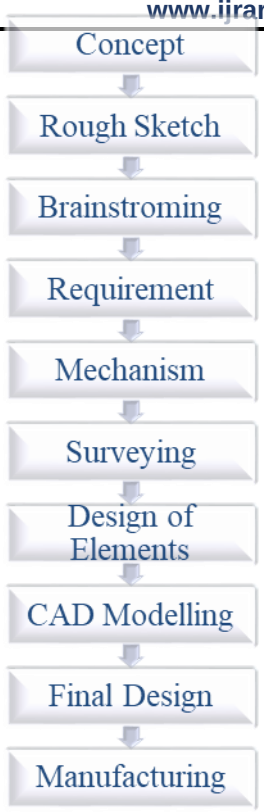


Figure 1. Designing Process

- **Concept**
  It is the basic idea on which we will is be working on.
- **Rough Sketch**
  It is the representation of the idea of the project which includes the rough drawing of project and block representation.
- **Brainstorming**
  After getting the rough idea about what is to done and brainstorming on that topic leads to various solutions. Brainstorming helps to decide the requirements.
- **Requirement**
  After deciding the purpose the requirements of the vehicle is to be decided to suit the functionality, cost and availability of market.
- **Mechanism**
  After deciding the requirement for project and to conclude the functionality of vehicle and make work, the mechanism of machine is decided that would work efficiently.
- **Surveying**
  Surveying for the parts and materials for project as per requirement and as per the functionality to fulfill the purpose.
- **Design of Elements**
  Values are obtained by calculations for material and parts to fulfill the purpose and the functionality as well as considering safety factors as per the requirements. According to the calculations surveying is done.
- **CAD Modeling**
  After deciding the parts, calculations, selecting the materials which will be used whole assembly is made in CAD modelling software to represent assembly of vehicle.
- **Final Design**

After designing the CAD model, removing any flaws and finalizing the design which is to be forwarded for manufacturing.

III. SELECTION OF MATERIAL

The material we have selected for all parts in our vehicle is mild steel. Mild steel is an alloy made by adding carbon and other elements in iron. This improves the hardenability,welability,ductility and overall tensile strength of metal. Also the machinabilty of mild steel is high and it can be easily used for different operations. Mild steel is cheaper and also available everywhere easily. Material composition and mechanical properties of mild steel:

Table 1.Chemical composition of mild steel

Material	Composition
Carbon	0.16% to 0.18%
Silicon	0.40% max
Manganese	0.70% to 0.90%

Sulphur	0.040% max
Phosphorous	0.040% max

Table 2. Mechanical properties of mild steel

Max stress	400-560 n/mm^2
Yield stress	300-440n/mm^2
0.2% proof stress	280-420n/mm^2
Elongation	10-14% min

IV. DESIGNING OF DIFFERENT PARTS AND THEIR CALCULATIONS

- **Body frame**

Main body is designed as per the boat, we have kept the body belly flat so that we have maximum surface tension on water to have maximum support on water. This design provides sufficient buoyant force on body to make it float.

Dimensions of Body

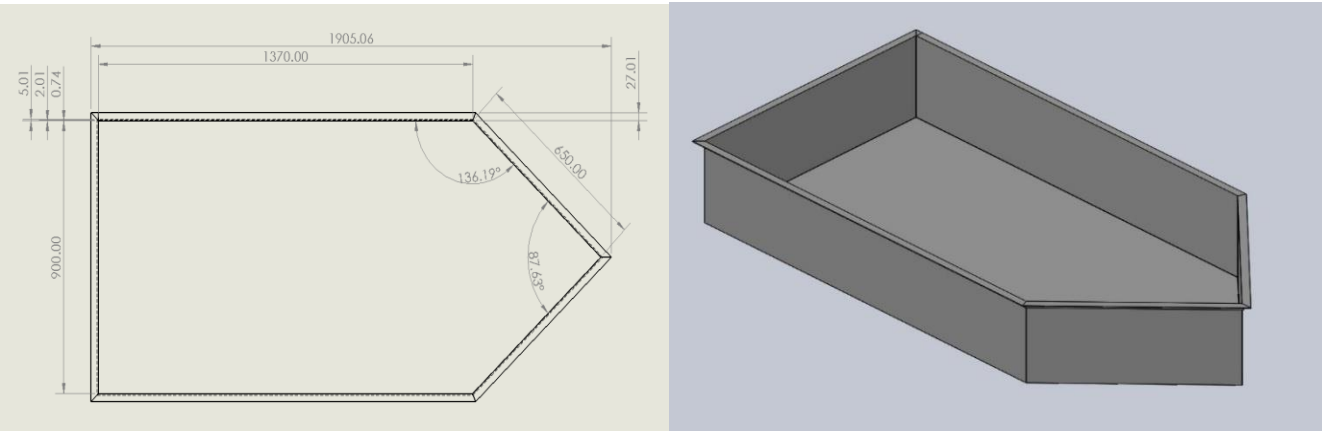


Figure 2. Dimensions of Body & Isometric View of Body

Volume of body=0.5m^3

Buoyant force= volume x density of water

Buoyant force=4912.2 N

Length till which body will sink:-

Weight = area x height x density of water x gravity

Height = 15cm

Centre of maas = $\frac{\Sigma \text{Mass} \times \text{centre distance}}{\Sigma \text{Mass}}$

Cg of the vehicle =0.95m

- **Seat and Chassis**

Seat and chassis is kept simple in construction makes it to maintain strength and cost effective which makes it ideal in our case. Chassis is constructed using 40 x 40mm square pipe as main frame and to support the seat square pipe of 35 x35mm is used and c channel is in front to support the frame of steering mechanism.

a. **Main frame**

It is in two conditions here

(1) Uniformly distributed load (2) Cantilever lever

Dimensions =40 x 40mm

Thickness = 1.5mm

Length = 1270 mm

(1)Deflection of frame

$y=\frac{WL^4}{24\,E\,I}$

Here

W= Force per unit length

L= Length

E= Young's Modulus of Material

I= Inertia of cross section

Obtained value= 12mm (↑)

(2) Deflection of frame (using PSG)

$y=\frac{P(2L^3-3L^3x\,x+x^3)}{6\,E\,I}$

Here

P = Load

L= Length

E= Young's Modulus of Material

I= Inertia of cross section

x= remaining length

Obtained value= 6.26mm (↓)

So overall value= 5.74mm (↑)

b. Supporting frame of seat

Dimensions =35 x 35mm

Thickness = 1.5mm

Length = 310.34 mm

Deflection of frame (using PSG)

It has cantilever condition

$y=\frac{P(2L^3-3L^3x\,x+x^3)}{6\,E\,I}$

Here

P = Load

L= Length

E= Young's Modulus of Material

I= Inertia of cross section

x= remaining length

Obtained value= 2.467x 10^{-1} mm (↓)

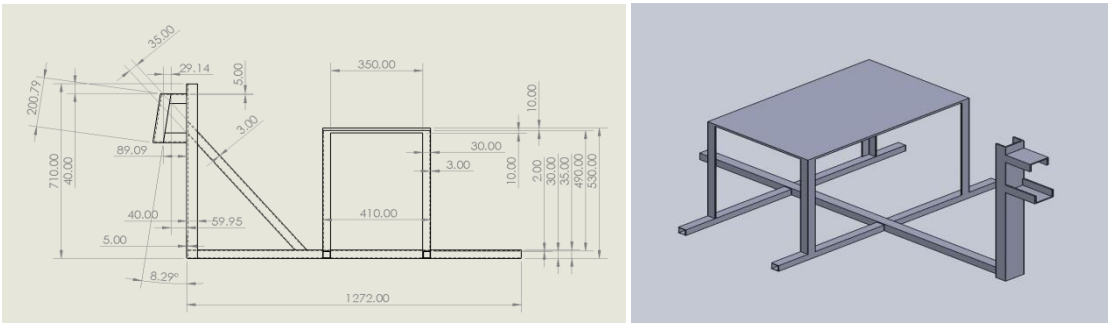


Figure 3. Side View of Frame & Isometric View of Frame

➢ **Shaft**

Shaft plays an important role in transmitting power or motion. We have used shafts in two places first at differential and second at steering rod. First rear section is divided into two sections right and left from differential.

Considering one section of rear

Considering torsion as well as bending on rod

$$d_o^3=\frac{16}{\pi\tau\left\{1-\left(\frac{d}{d_o}\right)^4\right\}}\sqrt{M_b k_b+\alpha\frac{Pd_o}{8}\left(1-\frac{d}{d_o}\right)^2+(M_t k_t)^2}$$

d_o = outer diameter

d=inner diameter

Since, its solid shaft so inner diameter=0

τ = maximum shear

M_b =Bending Moment

M_t= Torsion moment

Obtained value=1.61cm

As per market availability=2 cm diameter

Steering mechanism (front axle shaft)

Considering torsion as well as bending on rod

From PSG data book

$$d_o^3=\frac{16}{\pi\tau\left\{1-\left(\frac{d}{d_o}\right)^4\right\}}\sqrt{M_b k_b+\alpha\frac{Pd_o}{8}\left(1-\frac{d}{d_o}\right)^2+(M_t k_t)^2}$$

d_o = outer diameter

d=inner diameter

Since, its solid shaft so inner diameter=0

τ = maximum shear

M_b =Bending Moment

M_t= Torsion moment

Obtained value=1.85cm

As per market availability = 2 cm diameter



Figure 4.shaft of front and rear axle

- **Rudder**

Rudder is being used to give the direction to the floating body in fluid. In our vehicle we have integrated steering rod wheel with rudder so that simplicity can enhanced as well as switching hassle in steering mechanism while going from land to water vice versa.

Turning angle=70°

Area =0.166m^2

Total force acting on surface =1.016kN

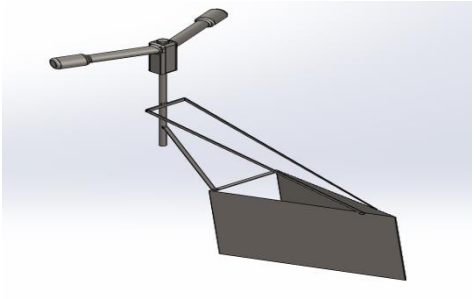


Figure 5. Rudder

- **Flappers**

In order to give motion to the body in water, flappers (paddles) are provided with rear wheels so that power can be transmitted from engine through the rear axle shaft of wheel.

Drag force

$F_d = \frac{1}{2} \times \rho \times V^2 \times A \times C_d$

Where

F_d=Drag Force

ρ = density

V=velocity

A=area

C_d=coefficient of drag

F_d = 198.37 N

Now Lift Force

$F_L = \frac{1}{2} \times \rho \times V^2 \times A \times C_L$ …….reference

$= \frac{1}{2} \times 1000 \times 0.0254 \times 4.166^2 \times 0.12$

Where

F_L=Lift Force

Rho = density

V=velocity

A= area

C_L= coefficient of lift

∴ F_L= 1131.234 N

∴ Resultant Force $= \sqrt{(F_D)^2 + (F_L)^2}$

$= \sqrt{(198.37)^2 + (1131.2)^2}$

∴ **Resultant Force = 1149.34 N**

Dimension for flapper= 8*15cm

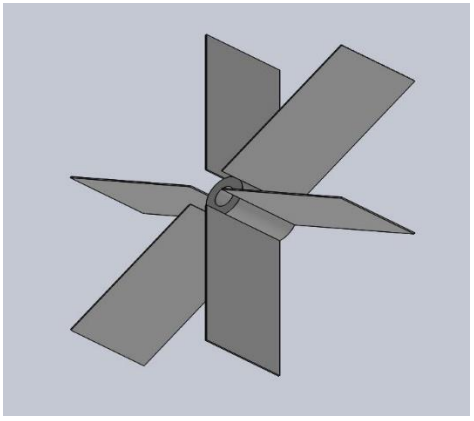


Figure 6. Flapper

➢ **Brake Calculation**

Weight at front wheel

$$W_f=\left(\frac{c}{L}\right)\times W+\left(\frac{h}{L}\right)\times\left(\frac{w}{g}\right)\times D_x$$

W_f = 1073.078 N

Force at front wheel during braking

F = $\mu \times W_f$ (μ=0.7) and taking FOS=1.5

F=1126.731N

Torque = F×r {D=130mm; r=65mm }

=1329.87×0.065

Braking Torque = 73.23 Nm

V. RESULT

Calculated values:

Table 3 Result of vehicle

AMPHIBIOUS VEHICLE	
Body Type	Boat
ENGINE AND GEARBOX SPECIFICATIONS	
Displacement	145.5cc
Maximum Power	6.8kW@4000rpm
Maximum Torque	17Nm@3000rpm
PERMANENT RATIOS	
Primary	1.42
Secondary	2.3
VARIABLE RATIO	
1st gear	4.75
2nd gear	3.17
3rd gear	2.34
DIMENSIONS & WEIGHT OF VEHICLE	
Overall Length	1905.06 mm
Overall Width	900mm

Overall Height	525 mm
Ground Clearance	178mm
Wheelbase	1981.2mm
Wet Weight	140 kg
Fuel Tank Capacity	1.25litres
SUSPENSION & WHEEL TRAVEL	
Modulus of rigidity	1845.28 kgf/cm^2
Stiffness	50kN/m
TYRE SIZE & WHEELS	
Wheel Size	49 x 11 x 49 cm
PERFORMANCE & MILEAGE	
Top Speed	37.5kmph(on land)
	10-15kmph (on water)
CALCULATED VALUES	
Extreme Condition	1969.2 N
Rear Shaft Diameter	1.61cm≈2cm
Front Shaft Diameter	1.8cm≈2cm
Main Chassis Rod	40 x 40 mm
Seat Supporting Rod	35 x 35mm
Flappers	80 x 150mm
Centre of gravity height	254mm
Braking Torque (Theoretical)	73.23Nm
Braking torque (Practical)	95.33Nm
Buoyant force	4912.2N
Normal Condition	2852.1N
Extreme Condition	1969.2 N

The heap conveying limit of the vehicle after change will be approx. over 140kgs that will be a driver and a co – passenger

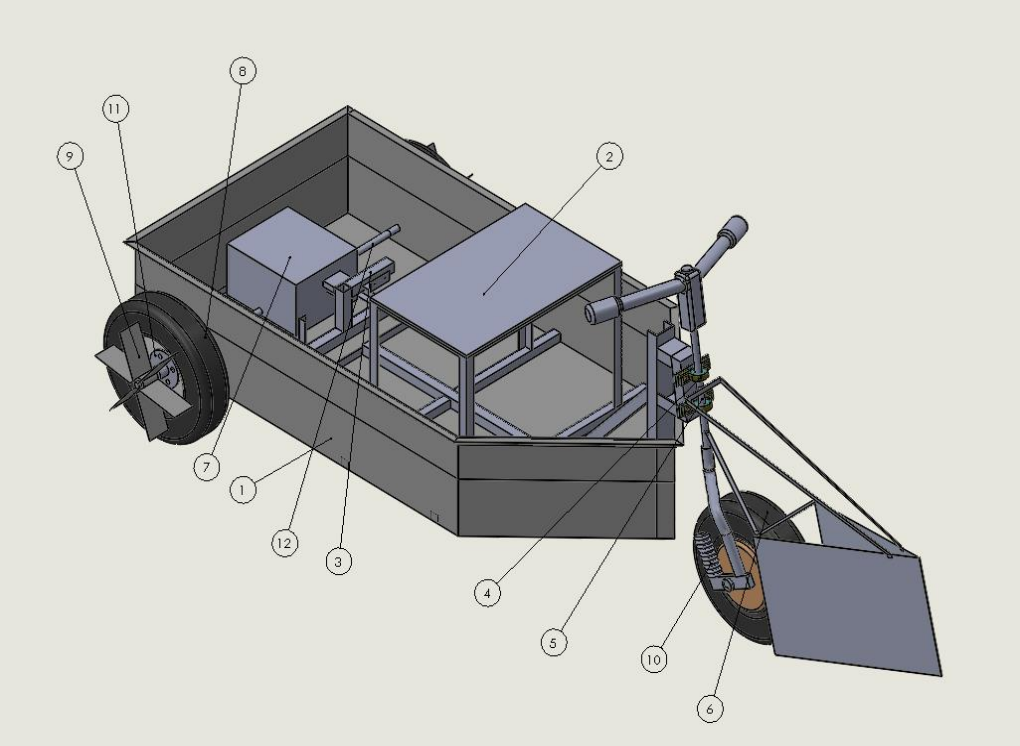


Figure 7.Complete Assembly of vehicle

Table 4. Assembly List

ITEM NO.	PART NUMBER	QTY.
1	BOAT	1
2	MAIN FRAME	1
3	ENGINE FRAME	1
4	BEARING	4
5	HANDLE	1
6	FRONT WHEEL	1
7	ENGINE BLOCK	1
8	REAR WHEEL	2
9	FLAPPER	2
10	SUSPENSION	1
11	HUB	2
12	POWER TRANSMITTING SHAFT	2

VI. CONCLUSION

This research is to design a mechanical vehicle of small type, filling the gap on the market. It is a new concept in India. With our ideas we are interested in investigating how to inspire the new generation to build an amphibious vehicle under the framework of creative thinking in the virtual world. In this stage, we have constructed the 3D model of amphibious vehicle according to design data. The development of body for amphibious vehicle is carried out based on the technical specification information required. This process started form design selection stage and will be completed with the fabrication process of body work.

VII. REFERENCES

1. Xiaowei Jiang and Xianchun Cheng,“ Research and Design on Amphibious Sightseeing Ship for Fitness and Entertainment”, Research Journal of Applied Sciences, Engineering and Technology, 2014, pp.5011-5014.
2. Hung-Cheng Chen,“On the Creative Design of Amphibious Vehicles in a 3DVirtual Classroom Using OpenSimInternational Journal of Information and Education Technology, Vol. 7, No. 7, 2017, pp.508-513.
3. Muhammad Zahir Hassan, Muhammad RazilRazali, MohdShazniHalid, “ Design and Development of Amphibious HybridVehicle Body Structure”, International Journal of Science and Research (IJSR) ,Vol. 2 Issue 5,2013, pp.220-223.
4. ZbigniewBurciui, Marek Kraskowski2,Mateusz Gerigk3, “ Analysis Of The Process Of Water Entry Of An Amphibious Vehicle”, 2016, pp. 6-13.
5. Bart Sitek and Wei Yang, “ Conceptual Design Of An Amphibious Vehicle: Vector”, ARPN Journal Of Engineering And Applied Sciences, VOL. 6, NO. 2, 2011, Pp. 102-107
6. Design of Machine Elements by V. B. Bhandari
7. Fundamental of Vehicle Dynamics by Thomas D. Gillespie.
8. Fluid mechanics by R. K. Bansal