A PROJECT REPORT

ON

"DESIGN OF SEMI-AUTONOMOUS AMPHIBIOUS ROVER"

Submitted by

1.SIDDIQUI AJNANUDDIN TAJUDDIN

2.KHAN FAHAD AFZAL

3.MUKADAM SHAFIQUE SADIQUE

4.QURESHI ABDUL RAZZAK

In partial fulfillment for the award of the Degree

Of

BACHELOR OF ENGINEERING

IN

MECHANICAL ENGINEERING

UNDER THE GUIDANCE

Of

Prof. RAHUL THAVAI

DEPARTMENT OF MECHANICAL ENGINEERING

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL,

NAVI MUMBAI – 410206

UNIVERSITY OF MUMBAI

ACADEMIC YEAR 2016-2017

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL

(Approved by AICTE, recg. By Maharashtra Govt. DTE,

Affiliated to Mumbai University)

PLOT #2&3, SECTOR 16, NEAR THANA NAKA, KHANDAGAON, NEW PANVEL, NAVI MUMBAI-410206, Tel.: +91 22 27481247/48 * Website: www.aiktc.org

CERTIFICATE

This is to certify that the project entitled

"DESIGN OF SEMI-AUTONOMOUS AMPHIBIOUS ROVER"

Submitted by

1.SIDDIQUI AJNANUDDIN TAJUDDIN

2.KHAN FAHAD AFZAL

3.MUKADAM SHAFIQUE SADIQUE

4.QURESHI ABDUL RAZZAK

To the Kalsekar Technical Campus, New Panvel is a record of bonafide work carried out by him under our supervision and guidance, for partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering as prescribed by **University Of Mumbai**, is approved.

Internal Examiner	**External Examiner**
(Prof.______)	(Prof.______)
Head of Department	**Principal**
(Prof. ______)	(Dr._______)

ANJUMAN-I-ISLAM

KALSEKAR TECHNICAL CAMPUS NEW PANVEL

(Approved by AICTE, recg. By Maharashtra Govt. DTE,

Affiliated to Mumbai University)

PLOT #2&3, SECTOR 16, NEAR THANA NAKA, KHANDAGAON, NEW PANVEL,NAVI MUMBAI-410206, Tel.: +91 22 27481247/48 * Website: www.aiktc.org

APPROVAL OF DISSERTATION

This is to certify that the thesis entitled

"DESIGN OF SEMI-AUTONOMOUS AMPHIBIOUS ROVER"

Submitted by

1.SIDDIQUI AJNANUDDIN TAJUDDIN

2.KHAN FAHAD AFZAL

3.MUKADAM SHAFIQUE SADIQUE

4.QURESHI ABDUL RAZZAK

In partial fulfillment of the requirements for the award of the Degree of Bachelor of Engineering in Mechanical Engineering, as prescribed by University of Mumbai approved.

(Internal Examiner) **(External Examiner)**

____________________ ____________________

Date: __________

ACKNOWLEDGEMENT

After the completion of this work, we would like to give our sincere thanks to all those who helped us to reach our goal. It's a great pleasure and moment of immense satisfaction for us to express my profound gratitude to our guide **Prof. Rahul Thavai** whose constant encouragement enabled us to work enthusiastically. His perpetual motivation, patience and excellent expertise in discussion during progress of the project work have benefited us to an extent, which is beyond expression.

We would also like to give our sincere thanks to **Prof. Zakir Ansari**, Head Of Department and **Prof. Riwan Shaikh**, Project co-ordinator from Department of Mechanical Engineering, Kalsekar Technical Campus, New Panvel, for their guidance, encouragement and support during a project.

I am thankful to **Dr. Abdul Razak Honnutagi**, Kalsekar Technical Campus New Panvel, for providing an outstanding academic environment, also for providing the adequate facilities.

Last but not the least I would also like to thank all the staffs of Kalsekar Technical Campus (Mechanical Engineering Department) for their valuable guidance with their interest and valuable suggestions brightened us.

1.SIDDIQUI AJNANUDDIN TAJUDDIN
2.KHAN FAHAD AFZAL
3.MUKADAM SHAFIQUE SADIQUE
4.QURESHI ABDUL RAZZAK

Preface

This project aims at the Design of Semi-Autonomous Amphibious Rover. This report contains the basic Introduction & Methodology used for Designing of Amphibious Rover along with the diagrams so that the logic may be apprehended without difficulty. Detail information, calculation with suitable pictures is provided with the report.

Attempt has been made to present the report content in simple, lucid and precise manner. Basic aim of the author has been to clarify the important concepts and to encourage the learners.

Unique features of this report are:

1. Text written in simple and easy to understand.
2. Study is done chapter wise and content are well explained.
3. Calculation shown is easy and simple.

We are grateful to **Prof. Rahul Thavai** who have shown extreme co-operation during the preparation of this report.

List of Figures

Nomenclature

P, Power of E-bike motor.

I, Gear ratio.

T_1, Torque at output shaft of motor

T_2, Torque at output shaft of gearbox

N_1, Speed in rpm at output shaft of motor

N_2, Speed in rpm at output shaft of gearbox

L_H, Length of hull.

L_{WL}, Length of waterline.

L_{BR}, Length to beam ratio.

B_{WL}, Beam length in water

B_{TR}, Beam to draft ratio

T_C, h, Draft length

M_{LDC1}, Load displacement capacity of hull part 1

M_{LDC2}, Load displacement capacity of hull part 2

P_1, Power of jet motor.

N, Speed in rpm at output shaft of jet motor.

D, Diameter of PVC pipe.

A, Area of PVC pipe.

D_1,D_2 Diameter of blade at inlet and outlet.

β_1, β_2 Inlet and Outlet blade angle.

B_2, Width of blade at inlet and outlet.

U_1, U_2 Linear velocity at inlet and outlet.

V_1, V_2 Absolute velocity at inlet and outlet.

V_{f1},V_{f2} Flow velocity at inlet and outlet.

V_{r1}, V_{r2} Relative velocity at inlet and outlet.

V_{w2}, V_{w2} Whirl velocity at inlet and outlet.

F, Axial thrust.

U, Rover linear velocity in water

η, Efficiency of jet drive.

FB, Buoyancy force

Abstract

An amphibious Rover (or simply amphibian), is a vehicle that is a means of transport, viable on land as well as on water. We have made amphibious rover that can work on both land as well as on Water by simply providing it with a waterproof hull or raft skirt and perhaps a propeller. Design is made like an army tank on inventor software by using certain set of parameter such as load to be handled, dimension constraint, speed etc. Design of each and every component such as main chassis, motor, shock absorber, propeller etc. and the analysis of the same are done using Autodesk inventor software. Fabrication of chassis and assembly of various components is done is shown in subsequent section below and analysis is also done and it is found that our design is safe.

Calculation of hull dimension using standard method of design of catamaran type hull and did the modeling of hull on inventor software of the same.

Main objective of this Project is to make a rover that can work on both lands as well as on Water. The Add-ons such as heat Sensing Camera, Close Circuit Camera, Mechanical arms can also be added to fulfill the desire Requirement of the Rover. To make Rover that can be used as Life Guard on beaches.

Table of content

Chapter 1

Introduction

INTRODUCTION

This section is intended for readers who want to gain an understanding of the basics of amphibious rover and its application in modern field of technology. The design and fabrication of an amphibious rover are described and applications of an amphibious rover are characterized. Amphibious rover is derived from an amphibious cycle is a human-powered vehicle capable of operation on both land and water. Saidullah’s Bicycle uses four rectangular air filled floats for buoyancy and is propelled using two fan blades which are attached to the spokes.

On terra amphibious rover in this study is powered by E-bike motor and further torque has been increased thus compromising with the speed while on Amphibia it is powered by four jet drive inspired by Hamilton jet drive and tri-maran hull is design, so that rover can sail on water. An electo-mechanical arm is installed on rover to perform basic operation of pick and place and can be used to clean small ponds and lake which is contaminated with foreign particles. Details of modelling and calculation of respective peripherals of terra and Amphibia is shown in subsequent chapters below.

The control part of the rover is shown in the next book named “Fabrication and Control of Semi-Autonomous Amphibious Rover”.

Chapter 2

Review of the literature and step involved

LITERATURE REVIEW

In Order to make a project, it is necessary that one should do a literature review and try to grasp the Base Knowledge related to project. Do the market survey to get knowledge about market condition, read various papers related to the project proposal, should do industrial survey and should surf on internet related to the postulate of project.

By doing this you will draw your inference regarding the materials, components, resources required in manufacturing, tools etc for the project with respect to market condition. You may get a chance to interact with the expert person for particular idea in your proposal. Expert person may endow you with some good suggestion or opinion regarding to your plan proposal. Sometimes, they can guide better, related to productions of certain assets which form as a unique part of the entire model because this kinds of parts are bit difficult to manufacture as a fresher person with negligible cognition or apprehension.

It is sometimes very necessary to surf on Internet to find your objectives plan so that you can preplan your objectives to fulfill the requirements of your outlook. Therefore, one should read the various papers related to the perception of their ideas and should try to acquire as much knowledge as can relate to that conceptualization. Surfing the internet and various blogs can lead you to build your model effectively and efficiently. It helps a lot when it comes to control part where you can find forums to communicate with people to resolve yours problems and sometimes to learn latest technologies. Some websites offers you step by step information and guide to fulfill the requirements.

Therefore one should do following things to get better proficiency regarding to the abstraction.

- Market survey.
- Industrial survey.
- Expert Advice.
- Internet Survey.

Chapter 3

Problem statement and objective of the study

PROBLEM DEFINITION

Our aim is to design and manufacture a rover which can work on land and as well as sail on water and control it wireless using radio module, and also making it work semi-autonomously.

OBJECTIVE OF THE STUDY

Usually in older times rovers are built to run on ground and they are very helpful for humans to accept various challenges such as saving people due to natural disaster, in military, for surveillance purpose etc. But this kind of rover cannot help us when something bad happen underwater. Therefore it is necessary to use basic theories to design a rover which can run both on land as well as on water. Therefore, we decided to built an amphibious rover which can go on water surface and can do survey, which can help human race to accept various challenges related to water such as to save human not knowing swimming, to clean any garbage or debris which contaminates water etc.

The objective is also to build an electromechanical arm which can be used to pick and place objects from point A to B on land as well as in water. The rover control will be semi-autonomously by using GPS to give him a small mission and it will do it automatically, that's why we had use APM v2.6 microcontroller to fulfill this challenge which has integrated environment on PC.

The Main objective of this Project is to make a rover that can work on both lands as well as on Water.

The Add-ons such as heat Sensing Camera, Close Circuit Camera, Mechanical arms etc. can also be added to fulfill the desire Requirement of the Rover.

- To make Rover that can be used as Life Guard on beaches.
- Rover with an inflatable raft skirt so that it can float on water.
- It can be used for military application for surveillance purpose.
- To make the design more compact and energy consumption required for operation should be less.

Chapter 4

Methodology

METHODOLOGY

Methodology is the systematic, theoretical analysis of the methods applied to a field of study. It comprises the theoretical analysis of the body of methods and principles associated with a branch of knowledge. The methodology is the general research strategy that outlines the way in which research is to be undertaken and, among other things, identifies the methods to be used in it. A methodology offers the theoretical underpinning for understanding which method, set of methods, or best practices can be applied to specific case, for example, to calculate a specific result.

Methodology deals with a system of methods used in a particular area of study or activity to get a final result. It is necessary that entire activity of the project to get final result should be co-ordinate properly so that entire network activity should take minimum time to complete the project. So that there will be less contingency.

Proper methods adopted and implementation of techniques can lead to complete the task in less time and thus significantly will be more efficient.

By keeping the following points in mind the proper techniques is used in order to complete this project on time and with less contingency. The various modelling and calculation of Terra and Amphibious portion are shown in below chapters.

Chapter 5

Modelling section of Terra and Amphibia

As discussed earlier that methodology is a system of action to be performed stepwise so that the final product can be produced in less contingency. In this chapter, readers can able to grasp modelling of various peripherals parts used in rover

Following activities are adopted to fulfill the desired result.

5.1. Modeling.

Designing of individual component forms a vital part and analysis for the same too. Visualization of the chassis dimension and design is the trickiest and challenging task to get the final result; the objective is to achieve a compact design so entire C.G. of the model should be balance precisely. Alteration in position of the motor and gearbox assembly, suspension assembly and tensioned mechanism lead us to the most compact design as per the dimension of the available peripherals such as motors, suspension system and gear box. After that, we made a rough sketch on paper, to see the appearance of chassis on paper shown in figure 1 below, we did small changes in dimension to provide best fit of various parts such as motor, gear box assembly and suspension assembly into it, so that entire design should be as compact as we required. Then we made a neat sketch on paper and further we jump into designing part on Autodesk inventor software.

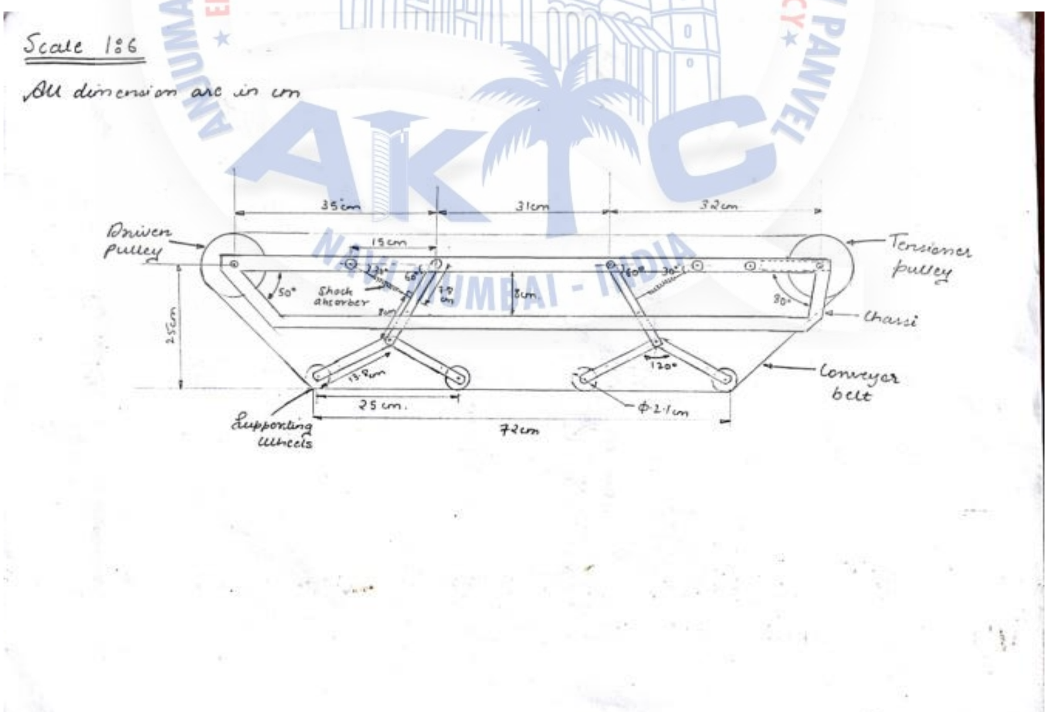


FIGURE 1: 2D SKETCH OF MAIN CHASSIS

Further we had calculated the torque required to drive the pulley for a particular load on it.

Design of following parts is done on Autodesk inventor and further we did the analysis of chassis too. Specification of motor shown below is 250 watts 2750 rpm having 0.70 N-m of torque capacity.

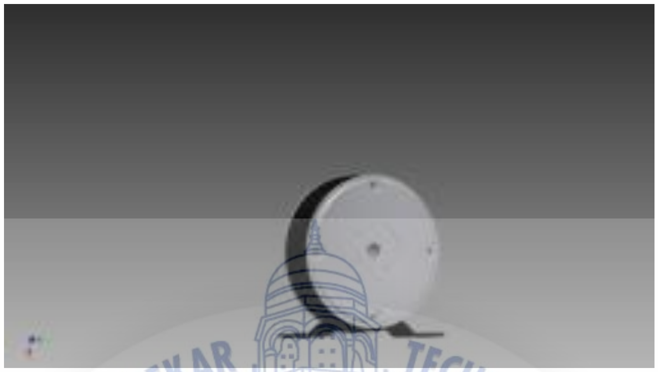


FIGURE 2: MOTOR ASSEMBLY

This torque available is much less to drive the entire rover in addition to the payload to be carried. It is must to increase the torque on expense of speed so that rover can work smoothly in addition to payload.

Therefore, we had used gearbox of gear ratio 1:30 to achieve this, by accomplishing this torque obtain is 21.23 N-m which is sufficient. Calculation of this is shown in subsequent chapter 6 below. Gearbox model is shown in the figure 3 below.

FIGURE 3: GEARBOX ASSEMBLY

The suspension system need to be designed congruously so that it can absorbs the shock from the supporting wheels evenly and its operation should be smooth. Suspension model is shown in the figure 4 below.

FIGURE 4: SUSPENSION ASSEMBLY

After modeling peripherals, modeling of main chassis is dominant. A chassis consists of an internal vehicle frame that supports an artificial object in its construction and use, can also provide protection for some internal parts. An example of a chassis is the under part of a motor vehicle, consisting of the frame (on which the body is mounted).We selected mild carbon steel material having concentric square section area which has high bending stress and can protect the entire peripherals inside it. Carbon steel is steel in which the main interstitial alloying constituent is carbon in the range of 0.12–2.0%.

Main chassis should be strong enough to bear high compressive as well as bending stresses while in operation.

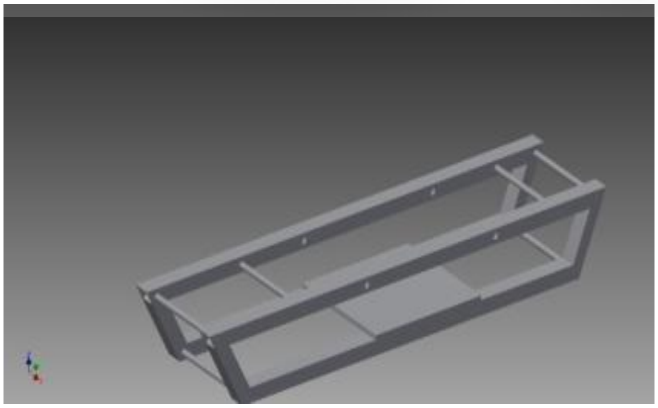


FIGURE 5: 3D VIEW OF MAIN CHASSIS

We selected the pulley to transmit the power from gearbox to caterpillar track. The material used for pulleys is nylon having high wear resistance. The pulley model is shown in picture 6 below.

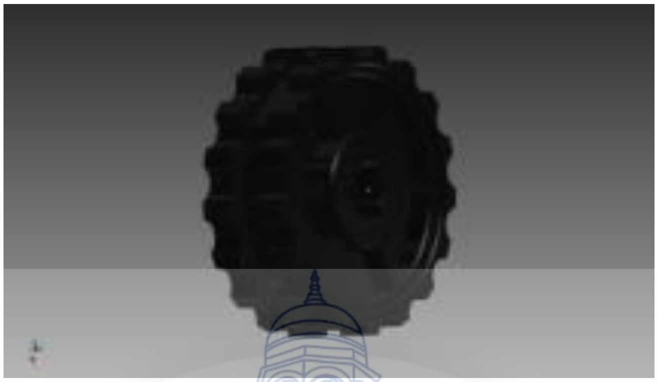


FIGURE 6: 3D VIEW OF PULLEY

After modeling all the peripherals, it's time to assemble all the components to get the final assembly. After assembly we will get the physical appearance of the model on computer before actual fabrication. Therefore, any changes can be done easily if it's to be done. The analysis of the chassis is shown in subsequent chapter 7 below. One side of caterpillar track can withstand a load of 100kg easily. The final assembly of main chassis is shown in figure 7 below.

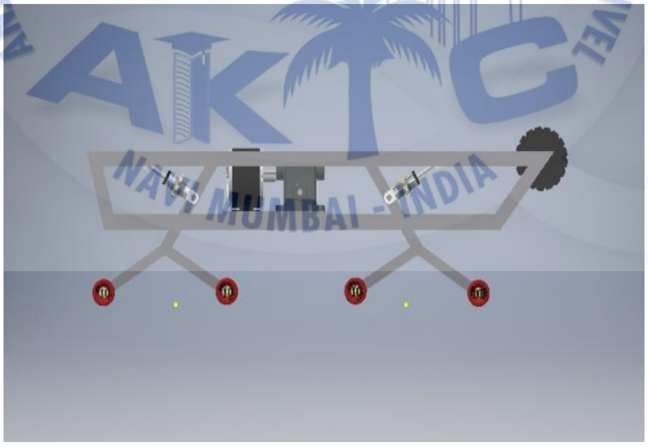


FIGURE 7: CATERPILLAR CHASSIS SIDE VIEW

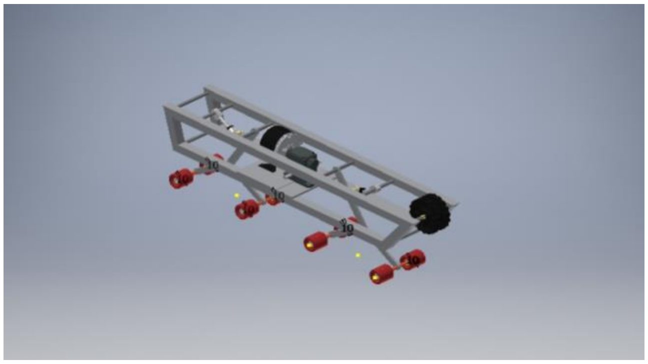


FIGURE 8A: CATERPILLAR CHASSIS ISO VIEW

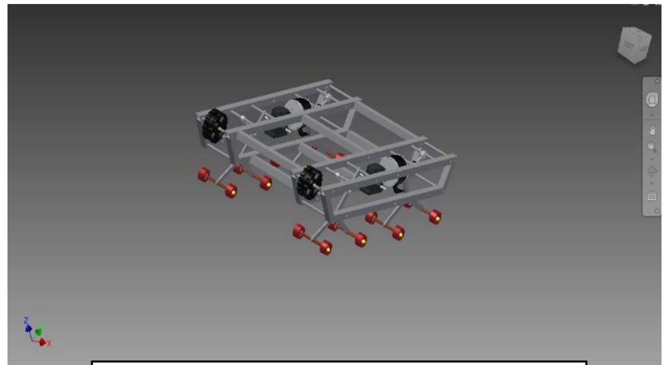


FIGURE 8B: FINAL CATERPILLAR CHASSIS ISO VIEW

After getting basics design parameters of hull theoretically further design of a 3D hull on Autodesk Inventor is executed. Figure 10 below show a 3D model of hull.

9.A ***9.B***

FIGURE 9: ISO VIEW OF HULL

After designing and modeling all the parts and peripherals, fabrication is done. After assembling all the peripherals components result obtained is seen in below figure.

FIGURE 10A: VERITABLE VIEW

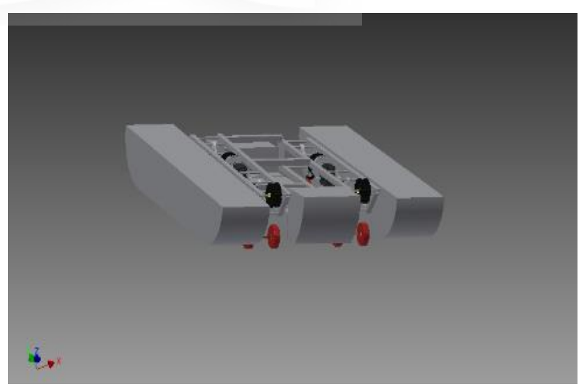


FIGURE 10B: CATERPILLAR CHASSIS WITH HULL

Calculation of 3D Hull and alternative of Hull i.e. inflatable raft skirt is shown in subsequent section 8.2 and 9.3 below.

After calculating the dimension of hull for a given payload, we need to further understand the propulsion system of the rover to provide the necessary hydrodynamic force in water. Using propulsion forces, ships are able to maneuver themselves in the water. Initially while there were limited number of ship propulsion systems, in the present era there are several innovative ones with which a vessel can be fitted with.

Today ship propulsion is not just about successful movement of the ship in the water. It also includes using the best mode of propulsion to ensure a better safety standard for the marine ecosystem along with cost efficiency.

Some of the various types of propulsion systems used in ships can be enumerated as follows:

1. Diesel Propulsion
2. Wind propulsion.
3. Nuclear propulsion.
4. Gas turbine propulsion.
5. Water jet propulsion. Etc.

All the propulsive system mentioned has some of the advantages and disadvantages depending upon the operating condition. We selected water jet propulsive system because it cause less noise propulsion, high speed jet velocity and less power loss as compared to diesel propulsion. In contrast the water-jet propulsion as a ship propulsion system is costlier to maintain which can cause problems to the user.

After selection of propulsion system we then calculated the outlet velocity of jet from jet drive to calculate the necessary thrust given by jet drive in the water. We too, calculated the discharge at outlet using continuity equation. In short, we done reverse engineering for jet drive as we know the dimension of all the components of jet drive, as they were easily available in the market.

If one has to make their own custom design then all the peripheral components of jet drive must be designed accordingly to fulfill the requirements.

After getting all the dimension of the peripherals we then designed the jet drive accordingly which suits best to the space available. Aim was to design the jet drive such that it should occupy less space and should give high thrust force in water. Design of various parts of jet drive and assembly of all the parts are done on Autodesk inventor 2016. The picture below shows the 3D design of jet drive.

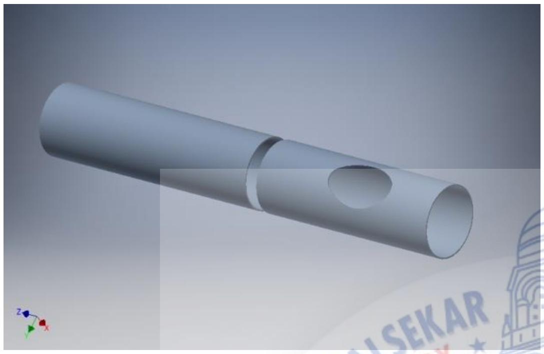


FIGURE 11A: PVC PIPE

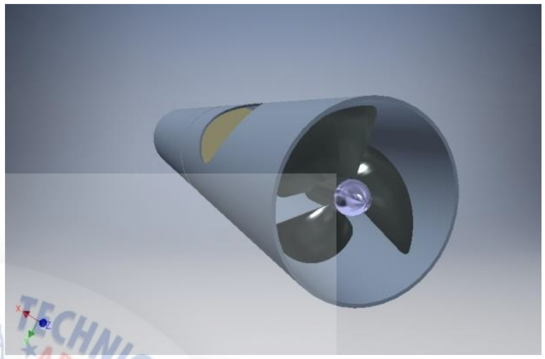


FIGURE 11B: ISO VIEW OF JET DRIVE

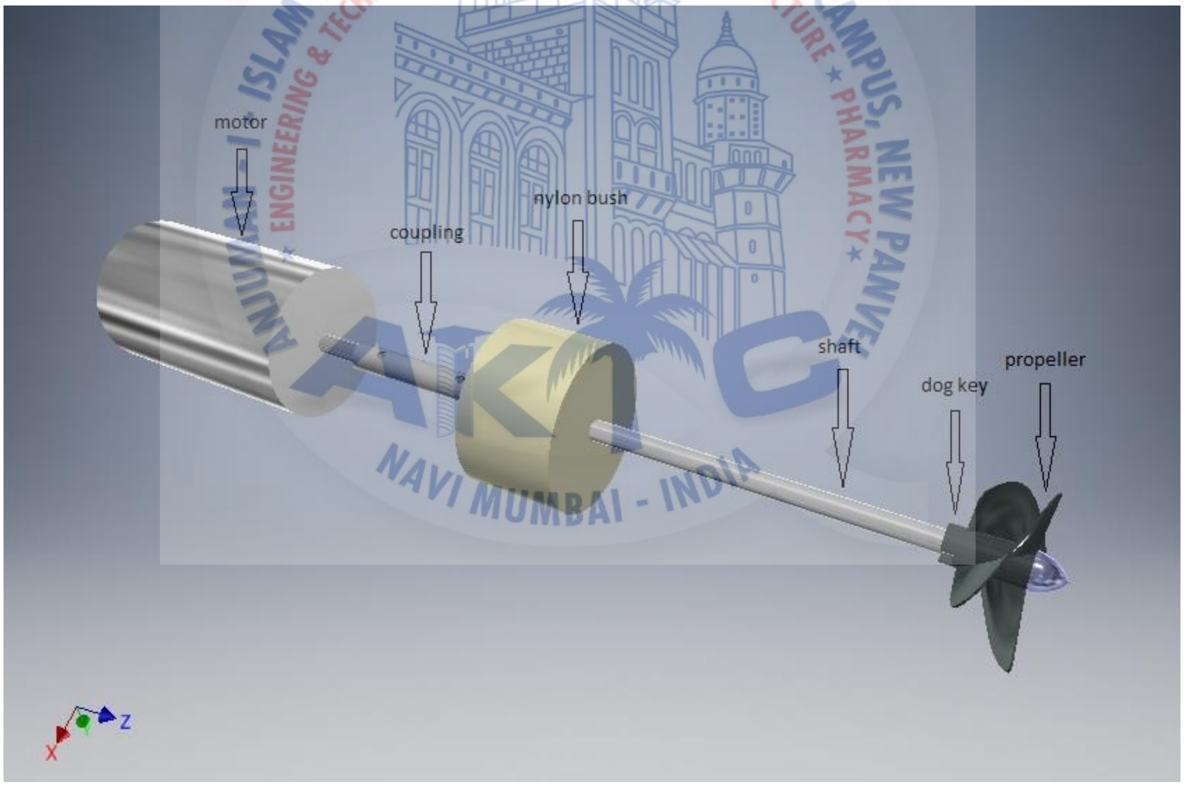


FIGURE 11C: PARTS AND ASSEMBLY OF JET DRIVE.

The working principle and calculation of jet drive is shown in subsequent section 8.3.

Chapter 6

Torque calculation of caterpillar track

Torque calculation:-

Finding torque at output shaft of gearbox for a given motor:-

Finding torque at output shaft

Motor specification: E-bike

Power=200 watt, N_1=2750 rpm

Torque developed 'T_1' will be, $P=\frac{2\pi N_1 T_1}{60}$

$$T_1=\frac{60P}{2\pi N_1}=\frac{60\times200}{2\times3.14\times2750}=0.707 \text{ N-m.}$$

We had use gear box to get output torque more

Gear ratio= I =30

$I=\frac{N_1}{N_2}$

$N_2=\frac{2750}{30}=91.66$ RPM

Now, torque available on this rpm

$$T_2=\frac{60P}{2\pi N_2}=\frac{60\times200}{2\times3.14\times91.66}=21.238 \text{ N-m.}$$

This much is the torque available at output shaft of E-bike motor (not on jet drive motor) which is must sufficient

Chapter 7

Analysis of chassis

Analysis of chassis

Software analysis and design includes all activities, which help the transformation of requirement specification into implementation. Requirement specifications specify all functional and non-functional expectations from the software. These requirement specifications come in the shape of human readable and understandable documents, to which a computer has nothing to do.

In addition to modeling the processes, structured analysis includes data organization and structure, relational database design, and user interface issues. Structured analysis uses a series of phases, called the systems development life cycle (SDLC) to plan, analyze, design, implement, and support an information system.

After designing all the parts and assembling all them, it is necessary to analyze the design for stress and strain. We did analysis on one side of caterpillar track chassis and thus application of 50kg of load is applied laterally on one side of caterpillar track and it was found that design is appreciably safe. The result obtained is shown in figure 12 below.

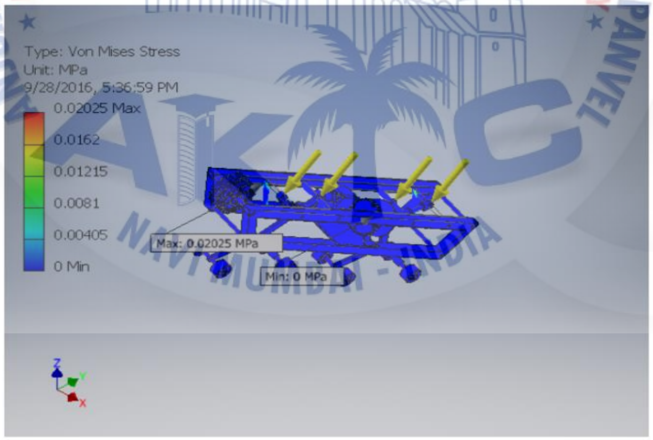


FIGURE 12: ANALYSIS OF CHASSIS

Chapter 8

Design section of Amphibious

8.1. TERMINOLOGY OF HULL

The hull is the watertight body of a ship or boat. Above the hull are the superstructure and/or deckhouse, where present. The line where the hull meets the water surface is called the waterline represented by 'w' in fig below.

In order to understand the calculation of hull one should know the basics terminology of ships and plimsoll load line for maximum loading condition in different density of water.

Terminology of ship:

The following are the standard terms used to describe the hull of the ship before it is put in the water. This few terms are basic and are as follow:-

Depth - Depth is the height of the hull from its highest point from its main deck to its lowest point.

Beam - It's width of hull at its widest point.

Keel - Keel is the principal structural member of a ship running lengthwise along the centre line from bow to stern to which the ship frame are attached.

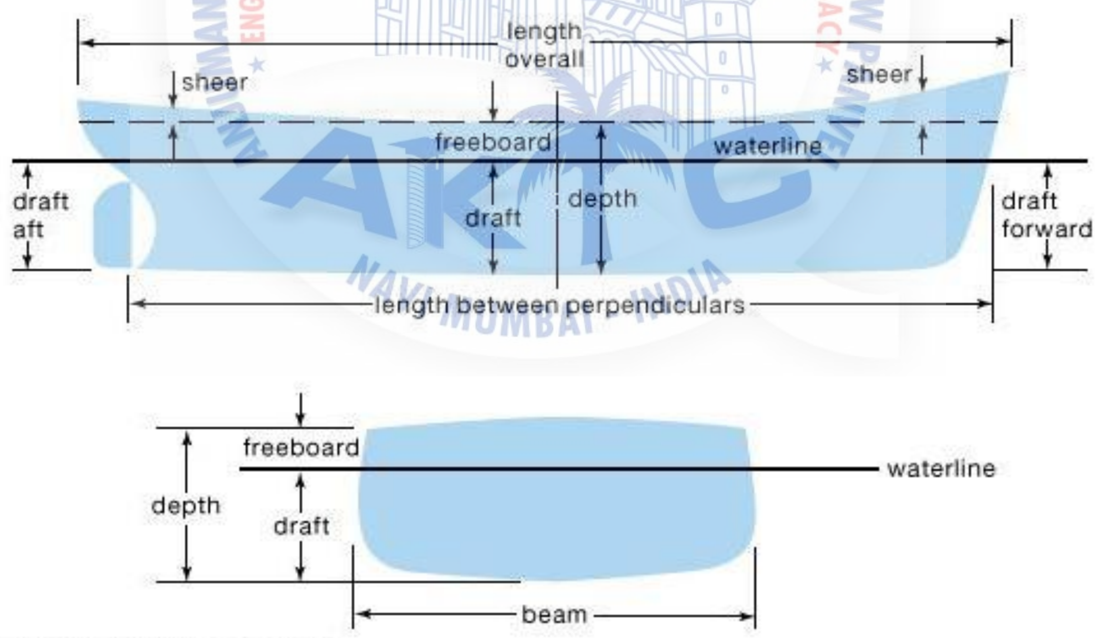


FIGURE 13*: *BASIC TERMS OF HULL

Waterline- It is the intersection of the surface of the water ship is floating in with the sides of ship hull.

After perpendicular (AP) - It is a vertical line drawn at the intersection of the design waterline and the aftermost point of the hull. For most commercial ship it is the point where generally rudder is located.

Forward perpendicular (FP) - It is a vertical line drawn at the intersection of the design waterline and the foreside of the stern of the hull.

Mid-ship - It is the horizontal distance halfway between FP and AP.

Length between perpendiculars (LBP) - It is the total horizontal distance between the two perpendiculars i.e. AP and FP.

Length overall (LOA) - It is the total length of the ship at its longest point.

Freeboard - It is the vertical distance which is free from water above sea waterline.

8.2. DESIGN OF HULL

After knowing all the basics hull parameters and terms, one can easily find out the hull dimension and design accordingly. In further section, one can learn about calculation of multi type hull i.e. tri-maran hull. Selected hull is divided into three parts.

To design a hull it is necessary to find various factors which are important and they are shown subsequently shown below.

Part 1

Length/beam ratio, L_{BR}

Let L_H= 1.30 m= 130cm, L_{WL}= 1.20m = 120 cm

$L_{BR} = \frac{L_{WL}}{B_{WL}}$ i.e $B_{WL} = \frac{L_{WL}}{L_{BR}}$

Take $B_{WL} = 0.225\text{m} = 22.50\text{cm}$

$L_{BR} = \frac{1.20}{0.225} = 5.33$

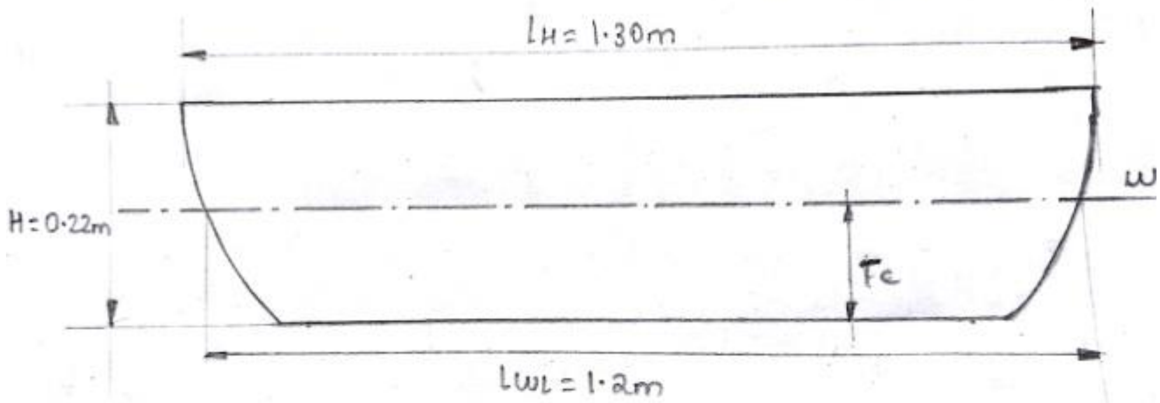


FIGURE 14: HULL SIDE VIEW

Now, beam/draft ratio BTR effects on the resistance of boat

$B_{TR} = \frac{B_{WL}}{T_C}$, Taking $B_{TR} = 2.2$

$T_C = \frac{B_{WL}}{B_{TR}} = \frac{0.225}{2.2}$ =.1022m =10.22cm

Mid-ship co-efficient, $C_M = \frac{A_M}{T_C B_{WL}}$

Assume, $C_M = 0.785$, $C_p = 0.59$, $C_w = 0.70$

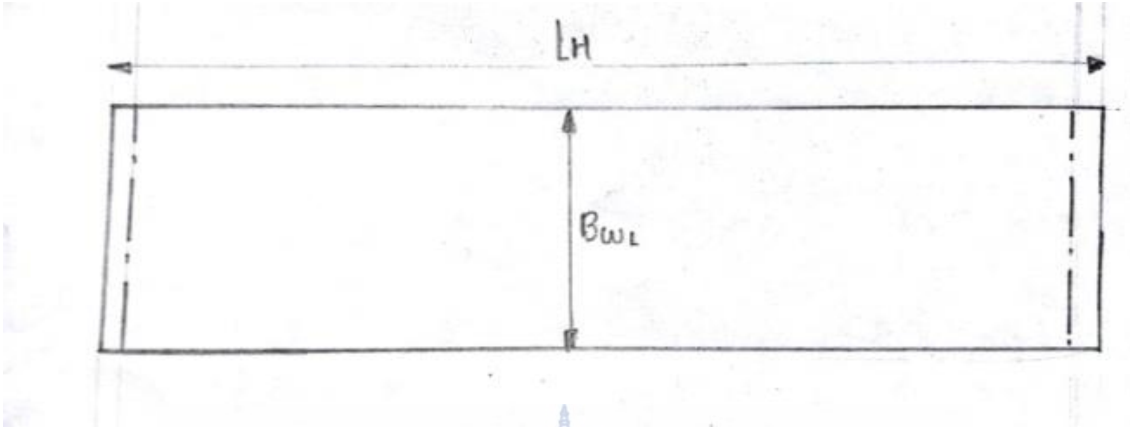


FIGURE 15: HULL TOP VIEW

Loaded displacement in KGs is

$M_{LDC1} = 2B_{WL}L_{WL}C_pT_CC_M 1025\ kg/m^3$

$= 2\times0.225\times1.20\times0.59\times0.102\times0.785\times1025$

$= 26.217\ kg/m^3$

This part is used and fixed on both side of main chassis. Therefore, total contribution to lift the load by this hull parts is approx. 53 kg under draft of 10.22 cm.

Part 2

Similarly

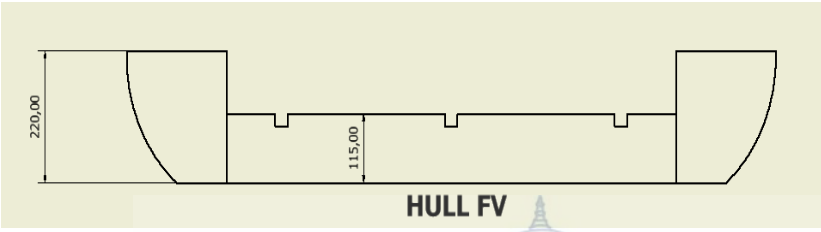
Length/beam ratio, L_{BR}

Let L_H = 0.90m = 90 cm, L_{WL} = 0.90m = 90 cm

$L_{BR} = \frac{L_{WL}}{B_{WL}}$ i.e $B_{WL} = \frac{L_{WL}}{L_{BR}}$

Take $B_{WL} = 0.30m = 30$ cm

$L_{BR} = \frac{0.90}{0.30} = 3$



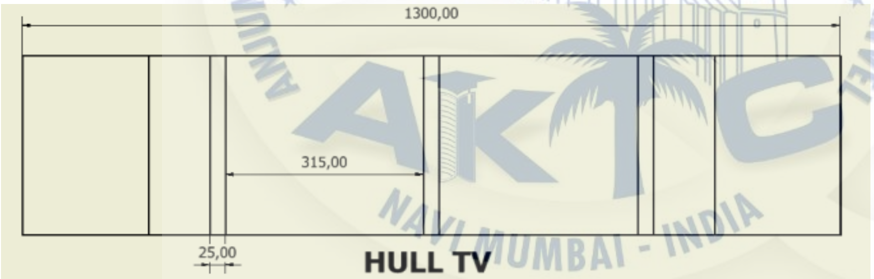
Now, beam/draft ratio BTR effects on the resistance of boat

$B_{TR} = \frac{B_{WL}}{T_C}$, Taking $B_{TR} = 2.72$

$T_C = \frac{B_{WL}}{B_{TR}} = \frac{0.30}{2.72} = 0.11m = 11$ cm

Mid-ship co-efficient, $C_M = \frac{A_M}{T_C B_{WL}}$

Assume, $C_M = 0.785$, $C_p = 0.59$, $C_w = 0.70$



Loaded displacement in KGs is

$M_{LDC2} = 2B_{WL}L_{WL}C_pT_CC_M 1025\ kg/m^3$

$= 2\times0.30\times0.90\times0.59\times0.11\times0.785\times1025$

$= 28.19\ kg/m^3$

Therefore, M_{LDC2} approx is $28\ kg/m^3$

Overall load can be lifted under draft of 11 cm is the sum of load can be lifted by two parts

Overall load= $M_{LDC1} + M_{LDC2}$

= 53+28

= 81 kg/m^3

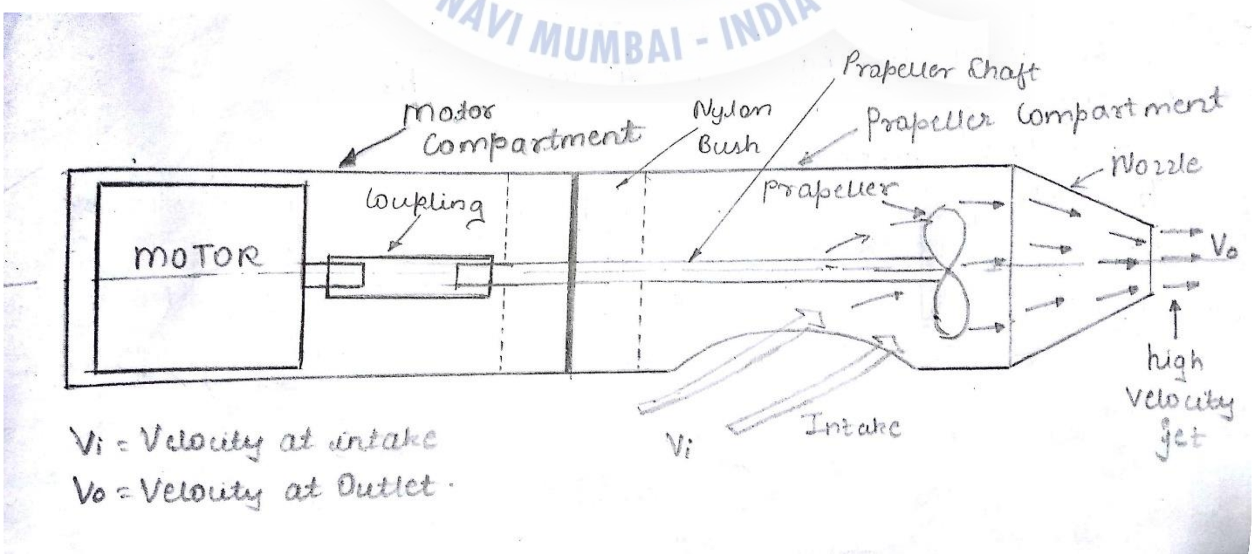
This design is safe for operating condition if in case the load increases above the calculated value the draft length will increase accordingly depending upon length of waterline(L_{WL}) or design waterline.

8.3. DESIGN OF JET DRIVE

WATERJET OVERVIEW

CONSTRUCTION AND WORKING OF JET DRIVE:-

A water jet generates propulsive thrust from the reaction created when water is forced in a rearward direction. It works in relation to Newton's Third Law of Motion – "every action has an equal and opposite reaction". A good example of this is the recoil felt on the shoulder when firing a rifle or the thrust felt when holding a powerful fire hose. Put simply, the discharge of a high velocity jet stream generates a reaction force in the opposite direction, which is transferred through the body of the jet unit to the craft's hull, propelling it forward (see diagram below).



PICTURE 16: SCHEMATIC DIAGRAM OF JET DRIVE

Construction:-

The design shown above consist of two compartment (refer picture 16):-

1) Motor compartment.
2) Shaft compartment.

1) Motor compartment

It consists of motor and coupling which has to be isolated from water outside the jet body. A nylon bush is made of required dimension to isolate or separate the two compartments as it is very important because we don't want water to enter into motor compartment. We used speb 7 a liquid solvent to stick and provide transition fit the nylon bush to the PVC pipe. Thus, separating the two compartments. On other end of motor compartments we did the same. We had wrapped and stick leather on motor body so that it provide the necessary damping action in operating condition.

2) Propeller compartment.

It consist of propeller shaft, propeller (rotor) and stator (not installed in our case). The propeller shaft has key on which the propeller is fitted. Finally this compartment is fitted on nylon bush with motor compartment. Nylon bush separate the two compartments and there is a hole in center through which propeller shaft passes from motor compartment to propeller compartment. It doesn't allow any leakages from propeller to motor compartment and prevent mechanical vibration of propeller too.

Working of jet drive:-

In a single hull (a hull at an extreme side) the jet unit is mounted inboard in the both after and forward perpendicular section. Water enters the jet unit intake on the bottom of the boat,

at boat speed, and is accelerated through the jet unit and discharged through the nozzle (not shown in this case) at a high velocity.
The picture above shows where water enters the jet unit via the Intake. The pumping unit, which includes the propeller and Stator (not installed in this case), increases the pressure, of the flow. This high pressure flow is discharged at the nozzle as a high velocity jet stream. The motor shaft which is drive shaft attached to the propeller shaft by means of coupling to turn the propeller.

Steering is achieved by driving the two jet motors in cross i.e. motor placed in front of right side of hull should start and motor place in back of left side of hull should start and vice versa. By doing this we rover will turn right and left taking axially turn.

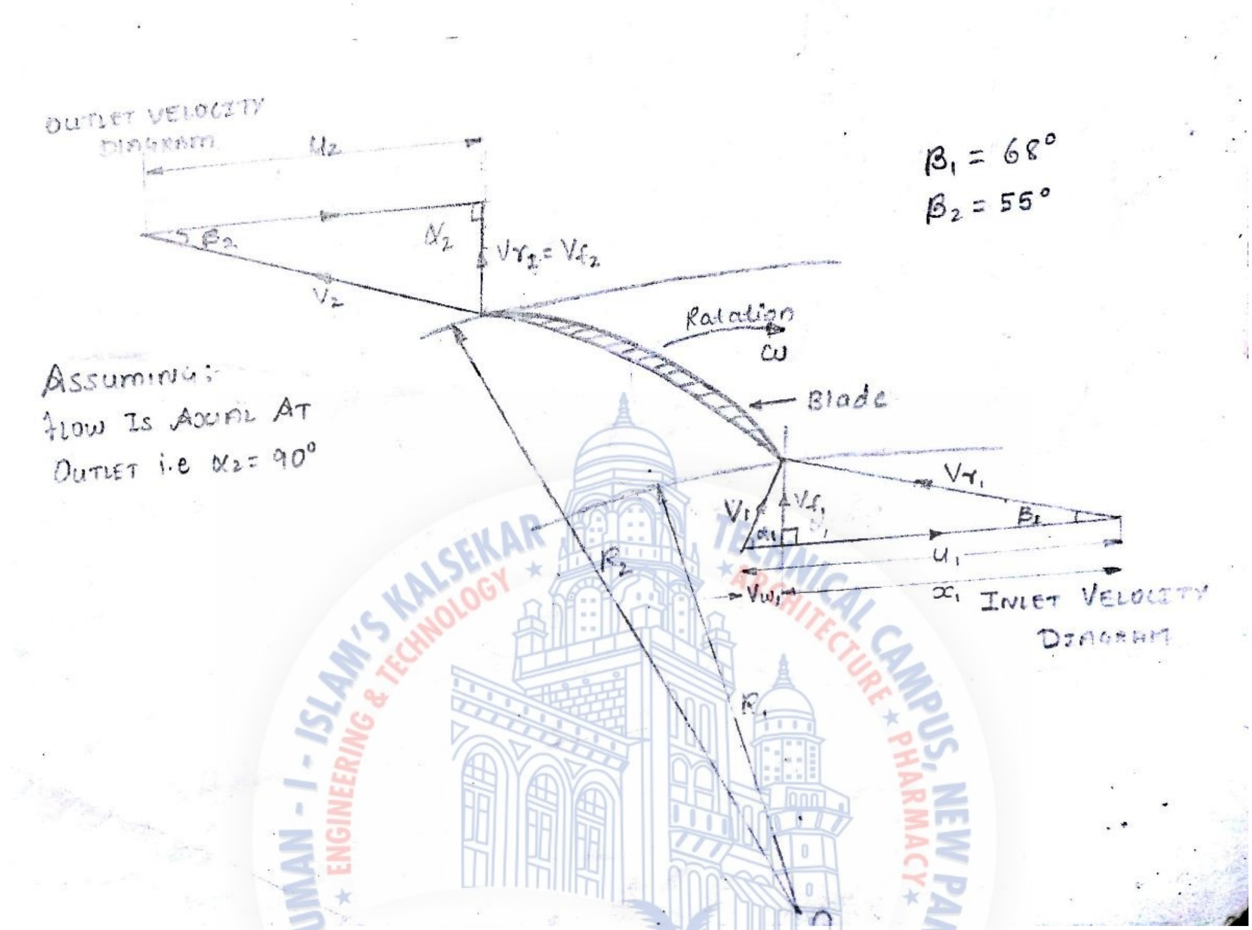
Reverse is achieved by starting two motors placed in front of either side of hulls. Thus, reversing of rover takes place.

SPECIFICATION OF WATER JET COMPONENTS:-

- Motor: 24v 5amp 5000rpm
- Coupling: 30mm length 60 mm hole
- Propeller: 2" Rotating Diameter: 47mm / 1. 9"; Pitch : 40mm /1, inlet angle= 75 deg, outlet angle= 20deg.
- Pvc pipe: 50mm outer diameter
- Shaft: 60mm outer diameter

CALCULATION OF JET DRIVE

Fig below show the inlet and outlet velocity triangle for propeller blade used in jet drive.



PICTURE 17: VELOCITY TRIANGLE OF BLADE

Power of motor, P = 60 watts

N = 1500 rpm

Diameter of PVC pipe (D) = 0.050m

Area of PVC pipe (A) = 0.0019625 m^2

Diameter of blade at inlet (D_1) = 0.0025m

Diameter of blade at outlet (D_2) = 0.0036m

Inlet blade angle (β_1) = 68˚

Outlet blade angle (β_2) = 55˚

Width of blade at outlet, $B_2 = 0.0003m$

$U_1 = \frac{\pi \times D_1 \times N}{60} = \frac{\pi \times 0.0025 \times 1500}{60} = 1.96\ m/s \approx 2\ m/s$

$U_2 = \frac{\pi \times D_2 \times N}{60} = \frac{\pi \times 0.0036 \times 1500}{60} = 2.826\ m/s$

From outlet velocity triangle,

$\cos(\beta_2) = \frac{U_2}{V_{r2}}, V_{r2} = \frac{2.826}{\cos(55)} = 4.92\ m/s$

${V_{r2}}^2 = {U_2}^2 + {V_{f2}}^2$

$4.92^2 = 2.826^2 + {V_{f2}}^2$

$V_{f2} = 4\ m/s$

We had assumed the flow is axial

$V_{f2} = V_{f1} = V_2$

From inlet velocity triangle,

$\sin(\beta_1) = \frac{U_2}{V_{r1}}, V_{r1} = \frac{2.826}{\sin(68)} = 4.34\ m/s$

${V_{r1}}^2 = {V_{f1}}^2 + {x_1}^2$

$4.34^2 = 4^2 + {x_1}^2$

$x_1 = 1.628\ m/s$

$V_{w2} = U_1 - x_1$

$V_{w2} = 2 - 1.628$

$V_{w2} = 0.372\ m/s$

$\tan(\alpha) = \frac{V_{f1}}{V_{w2}} = \frac{4}{0.372}$

$\alpha = 84.72^\circ$

${V_1}^2 = {V_{f1}}^2 + {V_{w2}}^2 = 4^2 + 0.372^2$

$V_1 = 4.5 m/s$

Discharge at outlet, Q_2

Q_2 = A×V_{f2}× B_2

Q_2 = 0.0019625×4× 0.0003

$Q_2 = 2.355{\times}10^{-6}\ m3/s$

$Q_2 = 2.355{\times}10^{-3}\ lit/s$

Now, axial thrust is given by

F = $\rho A V^2$

F = $\frac{1000\times0.0019625\times4^2}{4}$ = 31.4 Newton

Efficiency of jet drive is given by

Rover velocity in water, U = 1.5 m/s

$\eta = \frac{U\times F}{P} = \frac{1.5\times31.4}{60}$

η = 0.785

Chapter 9

Alternative of hull

9.1. ALTERNATE OF HULL (INFLATABLE RAFT SKIRT)

An inflatable boat is a lightweight boat constructed with its sides and bow made of flexible tubes containing pressurized gas. For smaller boats, the floor and hull is often flexible, while for boats longer than 3 meters (9.8 ft), the floor typically consists of three to five rigid plywood or aluminum sheets fixed between the tubes, but not joined rigidly together. Often the transom is rigid, providing a location and structure for mounting an outboard motor.

Some inflatable boats have been designed to be disassembled and packed into a small volume, so that they can be easily stored and transported to water when needed. The boat, when inflated, is kept rigid crossways by a foldable removable thwart. This feature allows such boats to be used as life rafts for larger boats or aircraft, and for travel or recreational purposes.

The most common term for inflatable boats is "rubber boat" although rubber is usually no longer used in their construction. Other terms used include "inflatable dinghy", "rubber dinghy", "inflatable", "inflatable rescue boat", and "rubber duck".

A raft is any flat structure for support or transportation over water. It is the most basic of boat design, characterized by the absence of a hull. Although there are cross-over boat types that blur this definition, rafts are usually kept afloat by using any combination of buoyant materials such as wood, sealed barrels, or inflated air chambers (such as pontoons), and are typically not propelled by an engine.

9.2. UNDERSTANDING THE CONCEPT OF BUOYANCY

In order to make rover float we need to displace amount of water equal to its weight, according to Archimedes principle.

Archimedes' principle describes the relationship between the buoyant force and the volume of the displaced fluid, but also the density of the displaced fluid i.e. Buoyancy = weight of displaced fluid.

We can write this principle in equation form as:

$FB = \rho \times V \times g$.

Where FB is the buoyant force, ρ is the density of the displaced fluid, V is the volume of the displaced fluid, and g is the acceleration due to gravity. It's very important to remember that the density and volume in this equation refer to the displaced fluid, NOT the object submerged in it.

This equation is helpful because you can use it to determine the buoyant force on an object. For example, say you submerge an object in water and find that the object displaces 1.0 cubic meter of water. Water has a density of 1.0 kg/m^3, so now we have everything we need to determine the buoyant force acting on the submerged object because we have the volume and density of the displaced fluid. Consequently, we also have the volume of the object because this is the same volume as that of the displaced fluid.

To calculate the buoyant force, simply plug in the numbers. Now our equation reads: FB = 1000 kg/m^3 × 1000m^3 × 9.8 m/s^2. Once we do the Calculation, we find that the buoyant force equals 9.8 kg-m/s^2, which is the same as 9.8 Newton's.

If the weight of the object is more than 9.8 N, then the object will sink. If it is less than 9.8 N, the object will float. If it is equal to 9.8N then it will neither float nor sink.

9.3. CALCULATION OF DIMENSION OF RAFT

In order to calculate the dimension of raft skirt required, reverse engineering is essential.

Consider a total weight of rover in addition to extra payload is 140kgs. We need to displace a volume or weight of water corresponds to this weight in order to make rover float. As discuss in above section 9.2 that weight of the object should be less or equal to buoyancy force.

Let m=140kg, diameter of raft=0.35m i.e. radius=0.175m,

For floating, weight of body=weight of water displaced.

Weight in Newton = 140×10 = 1400N

Volume of water displaced = $\frac{\text{weight of water displaced}}{\text{weight density of water}} = \frac{1400}{9800} = 0.1428\ m^3$

This much needs to be displaced in order to float the rover having weight 140kg in addition to extra payload.

Volume of water displaced by one raft = $\frac{\text{weight of water displaced}}{\text{weight density of water}}$

$= \frac{0.1428}{2}$

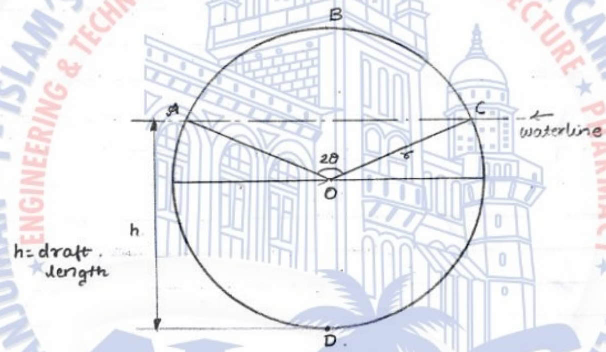
$= 0.0714\ m^3$

Let length of raft=1.5 m

Area ADCA=$\frac{\text{volume by one raft}}{\text{length of raft}}$

$= \frac{0.0714}{1.5} = 0.0476\ m^2$

This much is the area occupied to displace 0.0714 cubic meter of water by one raft



PICTURE 18: CROSS SECTION AREA OF RAFT

But area ADCA= area ADCDA + area of triangle ADC

$$= \pi r^2 \left[\frac{360-2\theta}{360}\right] + \frac{1}{2} 2r^2 \cos\theta \sin\theta$$

$0.0476 = (\pi \times 0.175^2)\left[\frac{360-2\theta}{360}\right] + 0.175^2 \cos\theta \sin\theta$

We get $\theta = 90.94 \approx 90°$

Now draft length h,

$h = r + r\cos\theta$

$=0.175 + (1.175\cos 90)$

$=0.175$ m $=17.5$ cm

It means that raft will have draft length of 0.175 m below sea water line or water line having load of 140kgs.

It means half of the portion of raft i.e. semicircular cross section of raft will be in water and rest will be above the water line.

If the load on the rover increases for same raft design then draft length will also increase and if load is less than 140kgs then draft length will be in between 0.175m depending upon magnitude of the load.

Chapter 10

Result and discussion

RESULT

By understanding the theories and calculation, thus we design and fabricated the chassis, hull and jet drive successfully.

DISCUSSION

While designing the parts and after assembling all the components, we came across various unnecessary Nuisances which thwart us and we were stuck at one place. Therefore, it is very necessary that you should take your decision more wisely and carefully. Some of the trouble we were faced are slack in chain, inefficient tensioner mechanism, inappropriate hull, improper supporting wheel, wobbling of supporting wheels etc.

We used gearbox to increase the power of rover, compensating with speed. We were using the single strand chain for transmitting power from gearbox to driving pulley. But due to more centre distance between gearbox and driving pulley there is slack which cause vibration and noise. Therefore, adjustment was done in center distance and slack was eliminated.

Replacements and proper guidance of supporting wheels was not done resulting into inefficient and jerky operation. Earlier small wheels were selected but this doesn't overcome the big hurdles and caterpillar track stuck on surface, damaging the track. Therefore, wheels with large diameter were selected to overcome the hurdles.

It is necessary to put the caterpillar track in tension, to avoid slack and slip. We made tensioner mechanism to put the track in tension but after implementing this, we were experiencing the slack. We then came across the stiffness of spring was less and degree of longitudinal distance provided to sliding bearing was too less. Therefore, we changed the spring with high stiffness to overcome the trouble but longitudinal distance can't be changed as it was fixed.

We wobbled, while selecting amphibious part we decided to make a hull and calculated the dimension accordingly, then we selected alternative of hull i.e. inflatable raft skirt. Because raft skirt taking less space and compact while hull taking more space and designing of hull is bit complicated. Inflatable raft require compressor and air reservoir which was making the system bulky and costly while making hull with thermocol was less costly. On the other for given amount of space available inflatable raft was taking more payload as compared to hull i.e. if we use 1.7m length and 0.4m diameter of raft, it will carry 200kg of load having 20cm of draft below water line while hull offer only 40 kg of payload which is quite less than raft. Due to bulky system and cost, we excluded inflatable raft skirt compensating with payload, we selected a hull and did the manufacturing of it.

Chapter 11

Conclusion and future scope

CONCLUSION

By gingerly studying the above chapters, one can easily get the rough knowledge on Amphibious Rover and can design their own chassis and ship hull or inflatable raft skirt depending upon their circumstances and requirements. The motive of the paper was to deliver how Amphibious Rover works, principles, methodology, selection of amphibious part and engineering behind it. Calculation done in above chapter 4 for hull and as well for inflatable raft skirt is distinctive for the one who had to make their custom design deliberately.

FUTURE SCOPE

- ✓ In future, anyone can adapt our design and overcome the difficulty of battery consumption.
- ✓ Design of suspension system can be changed to provide more flexibility to the rover, because due to small diameter of supporting wheels suspension assembly is not much effective.
- ✓ Design of track can be improved and custom design can be done because in our case we selected ready-made track which does not provide smooth operation as required.
- ✓ Different hull design can be done to make rover run fast in water and by using jet drive system.
- ✓ Overall size and weight can be compensated so that rover can work smoothly and efficiently.

Chapter 12

References

[1] "A textbook of fluid mechanics and hydraulic machines" by R.K. Bhansal, revised ninth edition, chp 4: "buoyancy and floatation", pg 131-162, published year 2010.

[2]Ship Resistance H.E. Guldhammer and Sv. Aa. Harvald, 1974

[3] Prediction of Power of Ships Sv. Aa. Harvald, 1977 and 1986

[4] MAN Alpha Propeller MAN Diesel & Turbo, Frederikshavn, Denmark, December 2011

Chapter 13

Appendix

SR. NO.	ACTIVITY	PROCEDURES OR TECHNIQUES TO BE APPLIED
1	Literature Review	Good communication skill is required during market survey, so as to interact with the local peoples and describing them your need in the best way possible. There may be possibilities that one can get dovetailed with expert personalities which may help them a lot. One should refer to journal papers related to their work and to grasp the best knowledge possible. Following steps are recommended for good literature review:- ▶ Market survey ▶ Industrial survey ▶ Expert Advice ▶ Internet Survey
METHODOLOGY		
1	Design	Visualize design and accordingly try to extract the best possible dimension (optimum) for chassis or any custom parts, so that they can be manufactured easily. After visualizing, embodiment the design and further convert your design into suitable dimension co-ordinate or do solid modeling using software, so that manufacturing of the parts can be achieved easily. Try to adapt tricky methods in designing and avoid dangling in the process, for any inconvenience.
2	Calculations	Study the engineering behind the processes, system, and its working principle and calculate theoretically the dimension of parts using appropriate formulas and theories. If possible, try to do same calculation with different methods and cross verify the answer, and conclude the result accordingly.

3	Analysis	After designing and assembly of all the parts one should do analysis of the robot, so that one should know the design is safe under working condition.
4	Fabrication	Use the best resources available to manufacture the parts and use crafty techniques, if certain slouch happens. Utilize the time properly so that manufacturing can be done on time, Avoid delay.
5	Control	In order to make a rover work it is important that it should be controlled precisely. Therefore it is necessary to use a Good micro-controller to achieve the same. APM v.2.6 which has Integrated Environment on P.C which is capable of forming various missions autonomously or semi-autonomously depends upon User's Choice can be used. Arduino can also be used as alternative. Selection of microcontroller also important.