ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Design of Hovercraft

Mohan Kumar G.R.
Assistant Professor,
New Horizon College of Engineering,
Bangalore.

B.V.S.Keerthana
Assistant Professor,
New Horizon College of Engineering,
Bangalore.

ABSTRACT
A hovercraft, or air-cushion vehicle (ACV), is a craft designed to travel over any smooth surface supported by a cushion of slow moving, high-pressure air, ejected downwards against the surface below, and contained within a "skirt." Hovercrafts are used throughout the world as a method of specialized transport wherever there is the need to travel over multiple types of surfaces. Because they are supported by a cushion of air, hovercraft are unique among all forms of ground transportation in their ability to travel equally well over land, ice, and water.

Small hovercraft are often used in physical activity, combustion, or passenger service, while giant hovercraft have been built for civilian and military applications to transport cars, tanks, and large equipment into difficult or hostile environments and terrain.

INTRODUCTION
What is a Hovercraft?

According to Webster, a hovercraft is "a transport vehicle which rides on a cushion of air ejected from an annular ring beneath it without any contact with the land or sea over which it travels."

Simply stated, an air cushion vehicle is one whose weight is supported only by air pressure that is trapped beneath it. It has no wings, wheels, or anything else below it other than pressurized air.

The subject is the "pure" hovercraft; one that does not use wheels, center-boards, or water rudders. The addition of such mechanisms, although of some possible use, will usually seriously affect the basic amphibious capability of the craft.
Throughout the development of the air cushion vehicle, it has been known also as a Ground Effect Machine (GEM), Surface Effect Vehicle (SEV). Cushion craft, and Hovercraft.

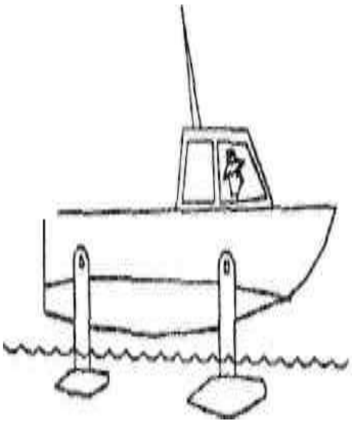
The invention of the hovercraft and its major development are British accomplishments. Hovercrafts have been in commercial use in Europe since the late 1960's, in Norway, Sweden, England, and France.

How dose Hovercraft differ
People often confuse a hydrofoil with a hovercraft. A hydrofoil, however, has little in common with an ACV. The hydrofoil requires two wings "flying" under the surface of the water at all times, a requirement that is certainly not at all an amphibious design like a hovercraft.

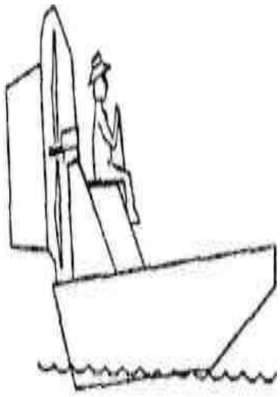
Another vessel that is sometimes confused with a hovercraft is the airboat. Airboats are commonly associated with the Florida Everglades swamp.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

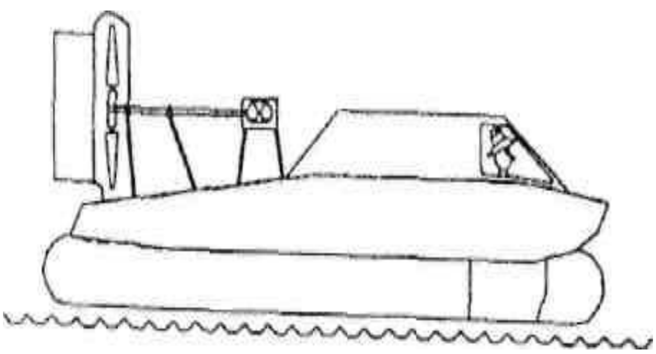
An airboat is little more than a flat-bottomed boat that is propelled with an air propeller and rudder in the rear of the craft, rather than a propeller and rudder in the water. See Figure for an explanation of the differences in these craft. The figure shows the basic operation of the three vessels hydrofoil, airboat, and hovercraft.



Hydrofoil



Airboat



Hover Craft

Why a Hovercraft

First of all, operating a hovercraft (also called an air cushion vehicle or ACV for short) is a lot of fun. Thinking is really needed when piloting one of these machines. They do not respond to controls like any other vehicle. The person piloting the hovercraft really is not in a positive control of an ACV at all times, because it is influenced so greatly by winds and any unevenness in the surface under them, That is why hovercraft are operated over water or over large fields, you need a lot of room to maneuver them.

One of the fascinating things about a hovercraft is that it is amphibious. A properly designed ACV can run at 40 miles per hour. On the way, it does very minimal damage to the environment. It is possible to clear typically, obstacles of about 6 inches in height at full speed without touching the hard part of the craft. This includes floating logs too. These are not felt even if they are lying flat along the water's surface.

A hovercraft at speed doesn't leave a wake, either. Unlike a power boat, no energy is expended in making the huge waves that trail behind a boat. The hovercraft leaves a few ripples and some bubbles thats all. Wake damage from an ACV is nonexistent. Collision damage, however, is a very real possibility.

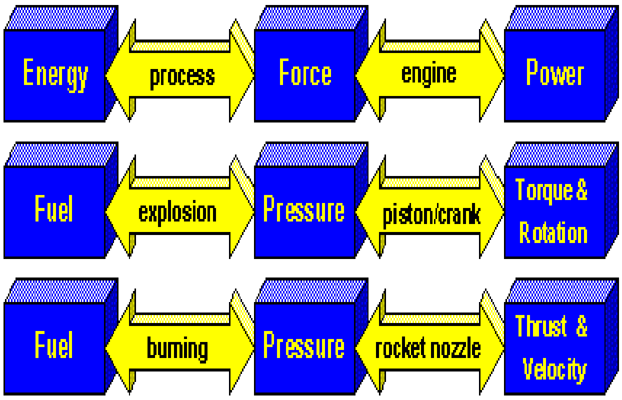
A hovercraft is environmentally safe, too. An ACV can operate directly over clam beds without disturbing them. These craft have even been driven over duck eggs to demonstrate the safety of the craft when operated in environmentally sensitive areas. They can even be driven over people, if there is enough hover height. One of the unique characteristics of a hovercraft is the amount of spray they kick up when operated over water.

Energy, Power and Force

Moving a vehicle, may it be on the ground, on the water, or in the air, requires a force to overcome the friction and inertia forces and to lift the vehicle to a different elevation. A force can be created from any kind of energy, like the energy contained in liquid fuel for an internal combustion engine, the electric energy stored in a battery or like solar energy being transformed by solar cells into electric power. To actually move an object, the force must be must be translated by some sort of engine into power, pushing the vehicle forward. Burning fuel in an open pan does not create a force and having a bottle of compressed air lying around creates a force on the bottles walls, but does not create any power output.

Energy may be static (fuel) or dynamic (flywheel), force is static and power is always dynamic. Power equals force times distance per time.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal



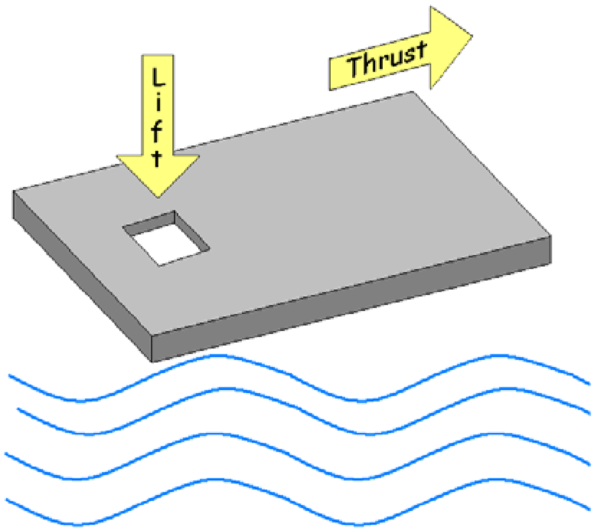
Process of converting stored energy into power which can be used to move a craft.

WORKING PRINCIPLE OF HOVERCRAFT

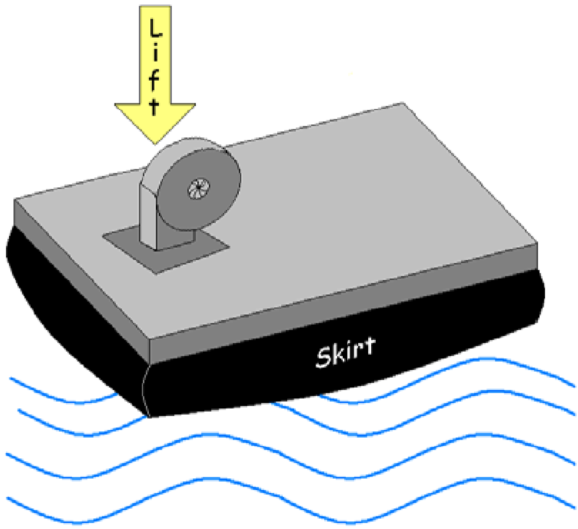
What is an Air Pressure?

Air Pressure can be defined by considering the example below.

Now let us consider a balloon which is filled with air, when the balloon is tried to squeeze it pushes back. The reason for this is just because the air inside the balloon is higher than that of the air outside. This is the concept of Air Pressure



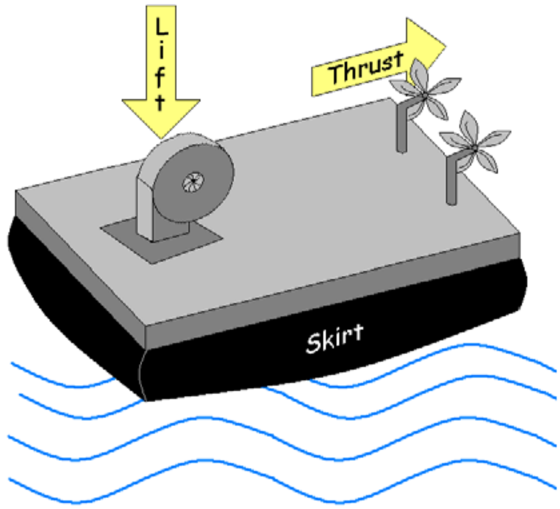
The Basic principle of Hovercraft is the combination of lift and the thrust. As seen from the figure above lift is provided from the bottom and the thrust is provided from the rear side.



As seen from the figure above a blower is placed vertically from the top, which produces air at a higher force. The air supplied by the blower produces a cushion of air underneath the tightly sealed "skirt" of the craft, thus lifting the craft over the surface. The region of trapped air underneath the hovercraft is called a "plenum chamber". Air flowing into the chamber creates a ring of circulating air that keeps the air from escaping.

Since more air is being forced into the plenum chamber all the time, the air underneath the craft is at a higher pressure than the air outside the chamber.

When gravity is overcome, the craft will float on a cushion of high-pressure air.



Now another fan is fixed horizontally in the rear side as shown in the figure above.

This fan rotates at very high speeds which sucks the air form beyond and releases it at a very force which pushes the air backward and pushes the craft forward.

Advantages of Hovercraft

- An ACV combines many of the best features of a boat, a snowmobile (yes, they run just fine on snow, too!) a dune buggy, an iceboat, and a 4-wheel drive vehicle
- With an appropriate enclosure over the cockpit (and maybe even the luxury of a heater,) an ACV could be operated in comfort year round.
- A hovercraft operates with much better mileage than a boat. While the boat wastes most of its available power in moving water out of the way at all speeds of operation, the hovercraft expends almost no energy in this wasteful manner.
- A hovercraft can be expected to get 2 to 4 times the gas mileage of a boat, and at much higher speeds.
- A hovercraft can be launched anywhere that has a gradual slope to the water. This means that marshy, swampy areas offer natural launching sites. No hard-sur¬faced ramp is necessary.
- A typical small ACV with a reasonably large engine should have no trouble attaining 40 miles per hour, while a larger craft might top out at 80 MPH or more.

Disadvantages of Hovercraft

- An air cushion vehicle cannot operate and remain under control on public roads. Roads are built with a natural curve, called a crown, down and out from the center to allow rainwater to run off quickly.
- A hovercraft is difficult to handle when operated in high winds.
- Another problem with the ACV is that it can be flipped upside down under certain conditions of sliding sideways at the same time the cushion pressure is low.
- A major criticism of hovercraft is that they really are noisy; the noise of a hovercraft is mostly from two sources, engine exhaust and propeller or fan blade-tip noise.

WHAT WE HAVE USED

1) Hull:

- Mild Steel pipe (25.4×25.4 mm) of 1mm thickness for the frame.
- Plywood (2439×1220 mm) of 6mm thickness for the wood work.
- Fevicol.
- Metal Paste.
- Fasteners.

2) Skirt:

- Skirt Material Used: Tarpaulin Material, Wax coated

3) Blower:

- Centrifugal Blower
- Discharge:

4) Motor/Engine:

- Power:2.25kW & 3.75kW
- Speed:2880rpm

5) Propeller:

Standard Specifications

- Material Used: Beach Wood
- Critical Speed:2500rpm
- Maximum thrust at 2500rpm:40kg
- Pitch angle:21 degrees
- Weight: 1.2kg
- Tip Speed:398.8mph

6) Duct:

- Mild Steel plate 4mm thickness 63.5mm width

- Mild steel pipes (25.4mmX25.4mm) 1mm thickness for support
- 6mm diameter steel rods
- Foam
- Brown Tape

Advantages of using a motor

Advantages of using electromechanical motors compared with IC engines are:

- Vibration is negligible in the motor
- The weight of the motor is less
- They are less noisy

LIFT AND LIFT PRINCIPLES

The lift components of the hovercraft produce the basis of its operation, because they allow the vehicle to traverse land, water and snow with minimal contact with the surface. Lift is achieved by producing a pocket of air that has a pressure greater than that of the atmosphere around the craft. This pressure differential times the surface area that acts upon generates the lifting force for the hovercraft. Low pressure high volume air is pushed via fans driven by diesel engines into a plenum chamber and because of the rubber skirt around the outside the air is forced under the craft.

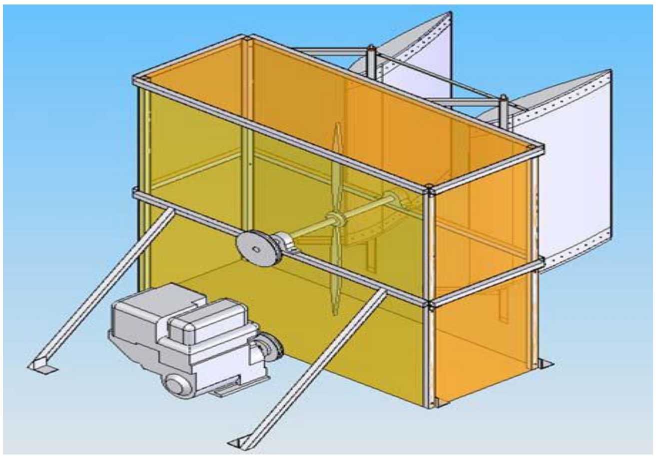
The lift fan pushes a large volume of air under the hovercraft. The air is prevented from escaping by the skirt. As the fan continues to force air into this cushion, the pressure under the hovercraft increases.

When the pressure under the hovercraft exceeds the weight of the hovercraft, the hovercraft begins to rise off the ground. Eventually the hovercraft raises high enough to lift the skirt off of the ground. Air begins to escape through the gap between the ground and the skirt (called the hover gap).At some point the hovercraft reaches an equilibrium point at which the amount of air being forced into the cushion cannot exceed the amount of air escaping through the hover gap. At this point the hovercraft is hovering at its maximum hover height. The hover height and hover gap which result at this stage can, within certain limits, be adjusted through the design process. On some full size hovercrafts, these can also be adjusted by the hovercraft pilot.

THRUST & THRUST PRINCIPLES

The ability of the hovercraft to float on a cushion of air makes it a versatile vehicle, but also makes it a challenge to move it from one point to another. The surface contact has been minimized, to reduce drag; to such a point that using the ground propels the craft is no longer sound. The majority of today's hovercrafts use a vertical propeller, but a few models use thrust vectoring of the lift engines. Both the propeller dimensions and engine operating conditions play a vital part in thrust.

Thrust concept & Analysis



A Thrust concept is quite simple. Propeller fixed in a duct is connected to the engine/motor is rotated at a very high speed.

The air beyond the fan is sucked by the propeller and at a very high speed is pushed by the propeller. This tends the craft to move forward.

Major Forces on the Propeller

Gyroscopic forces:

Gyroscopic forces are those which occur when the spinning propeller or fan is tilted. Gyroscopic forces act 90 degrees from the direction in which the spinning element is turned. This force is called gyroscopic precession. A thrust fan, for instance, will cause a slight nose-up tendency when the craft is rapidly turned to the right or left, and a nose-down tendency when the craft is turned the opposite way.

The direction of rotation of the prop or fan. CW or CCW, and the direction of the turn, right or left, determines whether the nose is pulled up or down.

An example: If the thrust propeller rotates CCW as viewed from behind the craft, a quick turn to the left will result in a slight nose-down tendency. The heavier the prop or fan. The higher the operating RPM, and the more rapid the turn, the more pronounced the gyroscopic effect will be. Gyroscopic forces are not normally a problem when designing a hovercraft, but the effect can be noticeable when using a large propeller.

Thrust Forces:

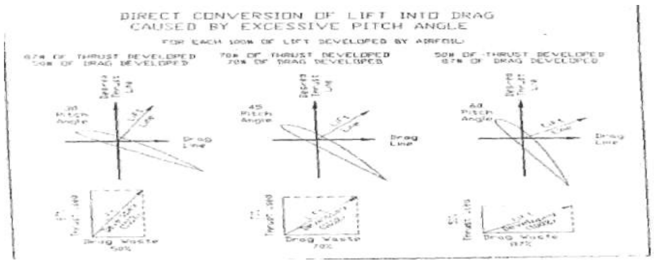
Thrust forces lie parallel to the fan or propeller's rotating shaft. Each blade takes its share of the total thrust developed by the fan.

Extreme Pitch Angle Greater Than 45 Degrees

Consider the direction in which thrust produced at small angles of measured pitch, such as 4 degrees. The thrust force will be acting almost parallel to the shaft spinning the prop. As the pitch angle is increased, the angle of thrust produced departs from being parallel to the shaft, approaching that of the direction of rotation.

At 45 degrees of pitch, any thrust produced will be roughly at 45 degrees to the shaft direction.

This means that half of any lift produced by a blade at 45 degrees measured pitch is converted directly into drag. Thus, we can see that pitch angles over 45 degrees are not a good idea at all. Extreme angles of pitch are used when the air is driving the prop, as in wind generators. The lift produced turns the shaft, producing useful energy output from the prop. In this case, you want the lift to be in the direction of rotation, not parallel to the shaft.



How to Measure Prop/Fan Pitch

Measurement of the mechanical angle between the face of a propeller or fan blade can most easily and inexpensively be made using a Sears Craftsman UNI¬VERSAL PROTRACTOR. The protractor measures angles within one degree, adequate for our hovercraft applications. An aviation application, however, would use a much more expensive and accurate bubble-leveling, vernier adjusting type instrument. Ibis amount of accuracy is not needed for our applications.

This instrument uses gravity as a reference line. Therefore, your driveshaft to the prop/fan in question must be exactly horizontal. If it is not, all measurements must have a correction factor applied to compensate for the lack of a true horizontal position.

Check the horizontal position by simply holding or attaching the protractor (it has a magnetic base) along the length of the driveshaft. Note any deviation from horizontal, and which direction. If the rear end of the vehicle is elevated by 2 degrees, then all future measurements made on the blades must have 2 degrees subtracted from them. The opposite is true, as when the driveshaft tilts downward at the rear.

To be entirely accurate, all theoretical measurements of blade angles should be taken with reference to the chord line of the blade. This is a line through the center of the blade, drawn from trailing edge through to the furthest point on the leading edge.

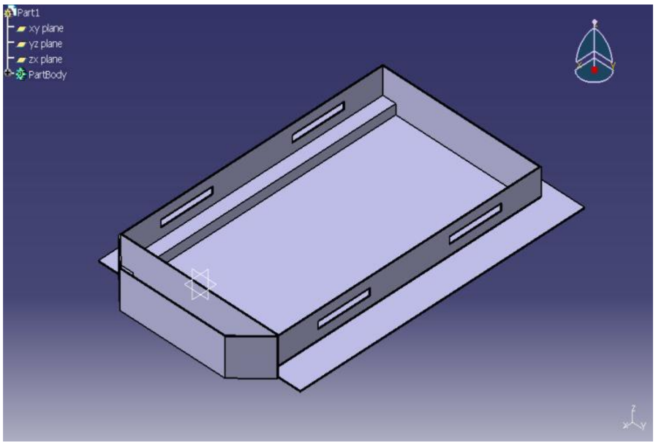
Since this line is not practical to measure to, we will use a rule-of-thumb for our applications, and assume a

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

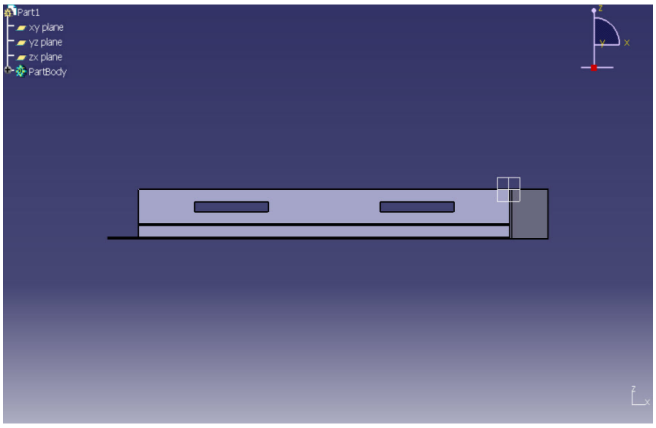
fixed angle of two degrees between the chord line and the face (flat side) of the blade.

DESIGN FILES

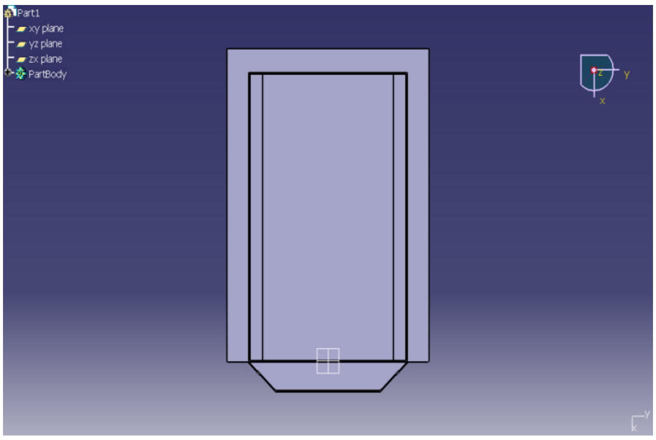
PART DESIGN



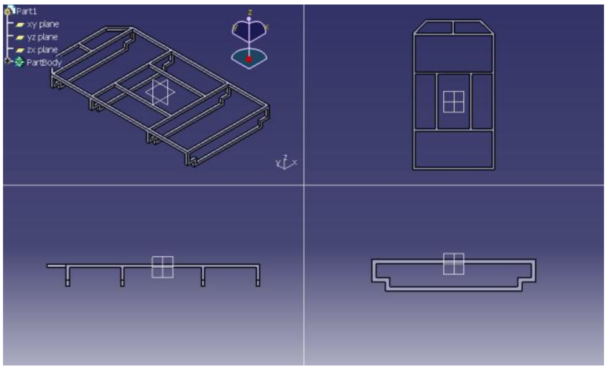
Isometric View of the Wooden Frame



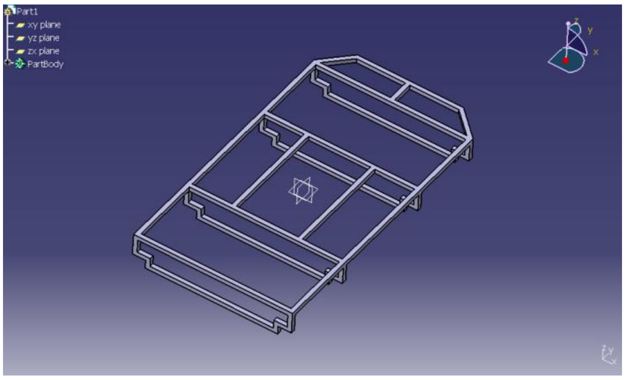
Side View of the Wooden Frame



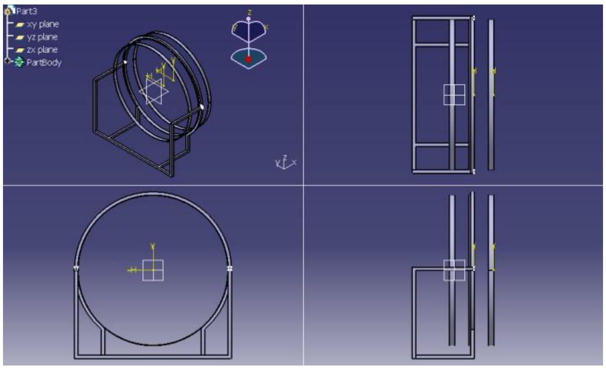
Top View of the Wooden Frame



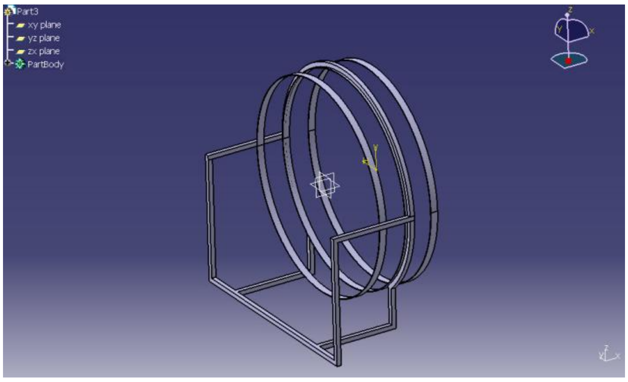
Top view, Front view and Side view of the Frame



Isometric View of the frame

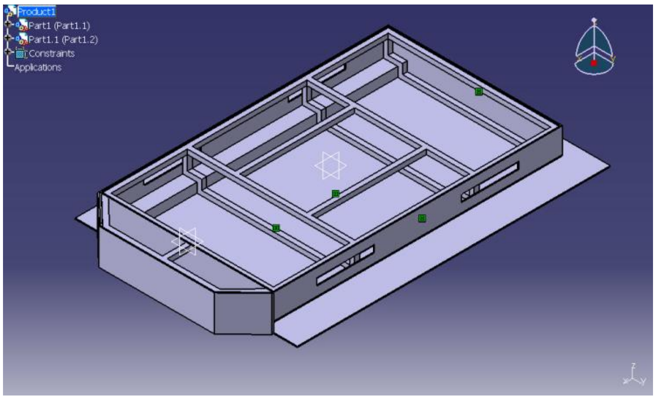


Top View, Front View and Side View of the Thrust Duct

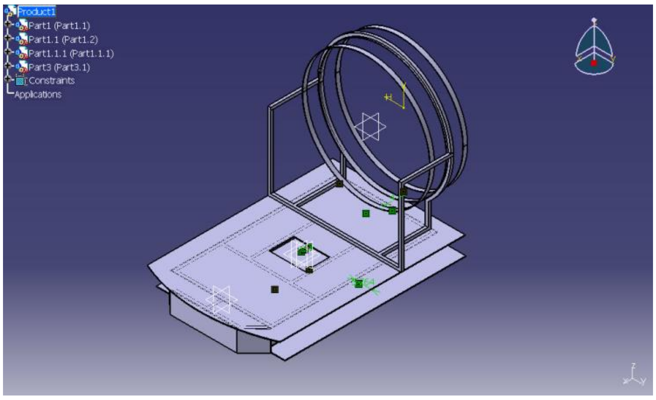


Isometric view of the Thrust Duct

ASSEMBELED DESIGNS



Hull Design



Final Design

MAIDEN FLIGHT

Learning to competently operate a hovercraft is about as difficult as learning to ride a bicycle; it takes time and practice. We have to learn how to handle your craft by trial-and-error method. The progress can be achieved slowly with simple exercises first, progressing to higher speeds and more complicated maneuvers later. Make the first outing or two in calm wind conditions.

The main thing to remember is to avoid like the plague three conditions which in combination spell disaster: I) the loss of skirt pressure 2) sliding sideways and 3) travelling at high speed. This combination can cause a bad overturn accident on land, and at least a thorough dunking on water.

A certain amount of preparation must be taken care of before making the first flight in a hovercraft:

Be sure the belt drives are properly adjusted for the first run. A loose belt will slip, causing wear and loss of thrust or lift as the case may be.

- Be sure that there are no miscellaneous nuts or bolts left loose. These can cause ex-pensive and dangerous damage to your propellers or fans.
- Be sure that nearby objects, particularly paper and other light material, is weighted down or removed from the area. Fans can kick up and suck in such things very easily.
- The maiden flight should be over land, so that there will be no need of the required marine safety equipment.
- A fire extinguisher should be included.
- However, along with a crash helmet. A motorcycle helmet is sufficient.

Problems we faced

- Balancing the impeller of blower was a tedious task.
- Getting a suitable skirt material of low density and stitching it according to our hull requirement was time consuming
- The thickness of the metal strip made us tedious task for bending in the construction of the duct.
- Mounting & Balancing of the propeller inside the duct was a risky job.
- Impeller of the Blower was broken due to vibrations. So it took very long time to get another impeller that suits our requirement.

Scope for the future

- A Generator of 5kW can be used.
- Speed Controller can be used to control the speed variations.
- Better finish to improve the appearance.

CONCLUSION

Hovercrafts are generally simple mechanisms in theory. Yet the process from theory to practical application is not as easy as it sounds. A many number

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

of problems exist and must be faced in order to attain a well functioning hovercraft. The plans and designs must be defect free. One must take under consideration the weight and the shape of each component in order to avoid problems such as instability and dysfunction. Our hovercraft is a ecofriendly vehicle as we use motors for both lift and thrust systems which is run by a generator which emits very less smoke as compared to engine . Our hovercrafts are vibration free as we use motors which do not produce any vibration. We used a wooden frame which could carry very heavy loads compared to that of the foam. Speed control was a tough task as we used a three phase motor in which speed controlling is difficult.

REFERENCES

1. Hovercraft as a Hobby, James Perozzo,revised edition, Universal Hovercraft.
2. Light Hovercraft Design, Third Edition.Hoverclub of America.
3. Hovercraft Construction and Operation Universal,Hoverclub of Great Britian.
4. The Design, Construction and Operation of the Light Air Cushion Vehicle, H.S. Fowler.
5. Hoversource: The Hovercraft Builder's Manual, P. W. Esterle.
6. Hovercraft Construction and Operation, R.J. Windt.
7. Light Hovercraft Handbook, Hoverclub of Great Britain.

WEBSITES

- www.hovercraft.com
- www.hovercruiser.org
- www.wikipedia.org
- www.hovercraftmodels.com
- www.afresearch.org