

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 5, May 2019

## Design & Development of Air Cushion Vehicle

S.Suneel Kumar<sup>1</sup>, K.Harshavardhan Reddy<sup>2</sup>, G.Prabhakar Goud<sup>3</sup>, K.Varun Teja<sup>4</sup>

Associate Prof, Department of Mechanical Engineering, Vidya Jyothi Institute of Technology, Hyderabad, Telangana,  
India.<sup>1</sup>

B.Tech scholar, Department of Mechanical Engineering, Vidya Jyothi Institute of Technology, Hyderabad, Telangana,  
India<sup>2,3,4</sup>

**ABSTRACT:** The Air cushion vehicle floats above the ground surface on a cushion of air supplied by the lift fan. Air is blown into the skirt through a hole by the blower. The skirt inflates and the increasing air pressure acts on the base of the hull thereby lifting up the unit. A blower incorporated in the thrust engine blows air backwards which provides an equal reaction that causes the vehicle to move forward and rudders are used to direct the airflow and steering can be achieved. Design and development of prototype with basics functions, design analysis is done to determine the relevant standard requirements for air cushion vehicle model. Solid and fluid interactions in the skirt and hull part are analyzed for different weak points. Analyze Bag, Segmented, combination type skirts for materials like, polyurethane coated nylon, rubber reinforced tarpaulin for improving the effectiveness of braking, steering and by enhancing attachment between skirt and hull for increasing safety of hull.

**KEYWORDS:** Hovercraft (Air cushion vehicle), design, parts, skirt, braking.

### I. INTRODUCTION

An air cushion vehicle popularly known as Hovercraft. ACV can be piloted on any surface and condition. These are piloted as aircrafts unlike as marine vessels, these vehicles hovers with a lift of 100mm to 600mm with an easy speed of 40kmph over any surface, up to gradient of 20 depending on requirement. They are used as special transportation in disaster relief, coast guard military, surveying and marine cleaning. Very large capacity vehicles are used in carrying the battle tanks, troops and military equipment in hostile conditions. This transportation is fast when compared with large vessels in the same transportation as no time is required to transfer huge things to a boat for reaching land, this helps in saving time and reduce handling.

Designing a prototype of air cushion vehicle which is durable and able to withstand rough terrain with least damaged skirt and best braking.

### II. PREVIOUS WORK

The first recorded design for a hovercraft was in 1716 put forward by Emmanuel Swedenborg, a Swedish designer and philosopher. The project was short-lived and a craft was never built. Swedenborg realized that to operate such a machine required a source of energy far greater than any available at that time. In the early 1950s the British inventor Christopher Cockerell began to experiment with such vehicles, and in 1955 he obtained a patent for a vehicle that was "neither an airplane, nor a boat, nor a wheeled land craft." He had a boat builder produce a two-foot prototype, which he demonstrated to the military in 1956 without arousing interest.

Hovercraft started as an experimental design to reduce the drag that was placed on boats and ships as they ploughed through water. The first recorded design for an air cushion vehicle was put forwarded by Swedish designer and philosopher Emmanuel Swedenborg in 1716. The craft resembled an upturned dinghy with a cockpit in the centre. Apertures on either side of this allowed the operator to raise or lower a pair of oar-like air scoops, which on downward

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 5, May 2019

strokes would force compressed air beneath the hull, thus raising it above the surface. The project was short-lived because it was never built, Swedenborg soon realized that to operate such a machine required a source of energy far greater than that could be supplied by single human equipment. Not until the early 20th century was a Hovercraft practically possible, because only the internal combustion engine had the very high power to weight ratio suitable for Hover flight.

In the mid-1870s, the British engineer Sir John Thornycroft built a number of model craft to check the air-cushion effects and even filed patents involving air-lubricated hulls, although the technology required to implement the concept did not yet exist. From this time both American and European engineers continued work on the problems of designing a practical craft

In the mid 1950s Christopher Cockrell, British radio engineer and French engineer John Bertin, worked along with similar line of research, although they used different approaches to the problem of maintaining the air cushion. Cockrell while running a small boatyard in Norfolk Boards in the early 1950s began by exploring the use of air lubrication to reduce the hydrodynamic drag, first by employing a punt, then a 20 knot ex-naval launch as a test craft. Cockrell persevered, and in 1959 a commercially built one-person Hovercraft crossed the English Channel. In 1962 a British vehicle became the first to go into active service on a 19-mi (31-km) ferry run.

### III. BASIC WORKING PRINCIPLE

Air cushion vehicle creates downward force. Lift force causes air to form as a layer in between vehicle surface and ground which reduces the friction and eases the forward moment, with this advantage we use thrust fan for the forward moment of hovercraft, the rudders are used to direct the flow of air from thrust fan for steering. For the stable air cushion effect we use skirt to accommodate the enough pressure of air for the lift of the vehicle thus it balance the vehicle, and helps in durability and long run of vehicle it also takes part in braking and handling of vehicle, the anchoring phenomenon occurs in ACV<sup>1</sup>'s that travel in high disturbance water and high tides if correct skirt and hull design is not accommodated. So water should be prevented from entering the lift producing chamber. In a high power ACV's the only chance or means of steering is by use of rudders, in some ACV's rotating propellers are used for steering but they become more complicated to handle and sometimes creates problem of braking and reverse moment of the vehicle but helps in faster steering and transverse movement.

### IV. DESIGN

#### Hull

Hull is printed in 3d with PLA, the design of hull is done in two sores such that the plenum chamber pressure is mostly taken by hull by dividing it into 2 parts one is in upper (with dimensions 177\*196.6) which houses all the required components to run the ACV. The lower one is designed (with dimensions 77\*196.6) in such a way that required momentum curtain effect is produced without causing damage to the skirt in long run

These design changes also affected the type of impact that occurs on hull of ACV in such a way that the skirt and enforcements in lower hull absorbs the most of it and prevent the hull from damaging

The lower hull is designed in such a way that it can be mounted with air bags in front of it so that damage on impact reduces considerably and improves the structural rigidity and helps in easy during starting of ACV in water

#### Skirt

Various skirt material was tested for the usage with various hole design patterns.

Rubber skirt (Thick used as tyres) are durable but lift achieved is less and friction is more, (thin sheets) are durable but scratches after few runs make their surface more rough and cause speed to reduce and stuck down in mud is observed.

---

<sup>1</sup>ACV's Air cushion vehicle (Hovercraft)  
Copyright to IJIRSET

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 5, May 2019

Canvas sheets (regular, cotton) are prone to leakage of air more often doesn't perform well in wet terrains and have issues with low pressure but braking improved, (synthetic) it was good in starting stage became hard when finger skirts are used prone to heavy damage in joined location in rough terrain with sharp objects but performs well in wet and soil lands easy to make



Fig.No.1 Skirt(Canvas)

Vinyl (PVC) combined with Nylon is great for most usage but tend to damage in braking when it is with segmented skirt but it is found out to be best bag skirt but got absolute when used outside for long time.

Polythene (HDPE) reinforced with rubber it is the good combination skirt material which is durable and worked well for my prototype got scratches at initial stage but was able to easily repair and repair is done without removing the skirt from hull

Various designs types of skirts are made from each material the finger skirt was easy to repair but hard to make and trouble in running, bag skirt was easy to make but damage and air leakage required to design or produce a new skirt. To reduce this repairing the best pattern was to use the finger skirt segments at highly damage prone spots and make a way for easy reparability.

The high chance of damage was seen in the front portion of ACV so the front portion is designed to be as finger or segmented type and other part where the heavy load occurs it is made to be a bag skirt, leaving the centre one large hole that is attached to skirt ring and is attached to the lower hull with holes for lift making less possible damage to the skirt and this made easy escape of air when lift fan is not running.

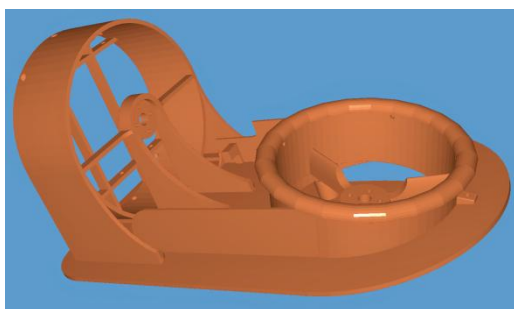


Fig No 2 Basic design

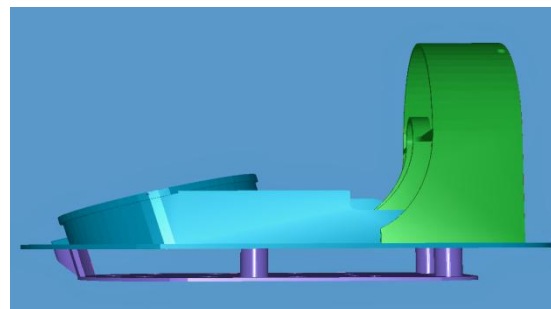


Fig No 3 Lower plate is used for Curtain effect

### Thrust duct:

The thrust duct is designed in such a way that it is easy to accommodate rudder for steering purpose and a protective mesh is over propeller chamber avoiding hands and wires into propeller improving safety and allows enough air for thrust.

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 5, May 2019

## V. DESIGN CALCULATIONS

The designing of ACV basically consider 3 forces acting on our ACV they are

1. Lift force
2. Thrust force
3. Drag force

### Lift force

The lift force that is required to produced by ACV should be greater than or equal to that of weight of ACV and less than peak pressure that can be handled by skirt, as air pressure reaches higher than the pressure produced due to weight of ACV it escapes through the holes provided under it decreasing the pressure until it reaches equilibrium, the ideal force required is the product of area of skirt and cushion pressure inside the skirt, for this calculation we need the gross weight of ACV and area of skirt under pressure (these two can be easily measured) and pressure inside skirt can be calculated

$$P_c = \frac{F_L}{A_s}$$

$P_c$  = Pressure inside skirt

$F_L$  = weight of ACV

$A_s$  = Area of skirt

$P_c$  is used to determine the pressure that opposes the lift force

Skirt and hull are designed to accommodate the required pressure and skirt should make a way to escaping air when pressure is high but instead of damaging the total skirt, a redesigned hull part that supports the escaping air without damaging the skirt (no holes for direct escaping of air, a plate is provided that contains holes for escaping of air and firmly attached it to the hull and thus higher control over pitching and yawing of the ACV is achieved we are able to control it over well with our equipment and made it stable and are stable.

### Thrust force

2: The thrust force is used for the forward moment of the ACV and this force works on Newton's second law<sup>2</sup>

$$F = M * a$$

Here the force required is developed by the propulsion system and is designed to make ACV travel in linear by these considerations the above formula change to

$$F = \left(\frac{W}{g}\right) \times \left(\frac{V_o - V_i}{t_2 - t_1}\right) \text{N}$$

W- Weight of ACV

G- Gravitational pull of earth

$V_o$ - Outlet velocity

$V_i$ - Initial velocity

$t_1$ - initial time

$t_2$ - final time

$$\left(\frac{W}{g \times (t_2 - t_1)}\right) = \underline{m} = \rho A v \text{ kg/m}^3$$

$\rho$ - Density of air inside the skirt

<sup>2</sup>  $F=M*a$  [The rate of change of momentum is directly proportional to the impressed force, and takes place in the same direction, in which the force acts]

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 5, May 2019

A- Propulsion area cross section

V- Velocity of ACV

The force that is required for the forward movement of ACV will be

$$F = m(V_e - V_i)N$$

$V_e$ - Entrance velocity

$V_i$ - Exit velocity from propulsion system

This thrust should be stable and continuous, and we should be able to control the speed of propeller for speed control of ACV and excessive speed may damage our ACV

### Drag force

The drag force will be our only resisting force after above two forces are resolved so we need to consider the drag force and reduce it until we get our requirements it is done by the following formula

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

$\rho$ -Density of fluid ACV is travelling

v-relative velocity b/w ACV & fluid

$C_d$ - Coefficient of drag

A- Area of ACV

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

From these calculations we got to determine that a cuboid with a half-sphere nose is best shape for us to work with considering all 3 forces with stability and controllability during steering & braking even streamlined body produce less  $C_d$  But makes it unstable.

As we consider a supporting frame for our skirt we need more consideration in shape so cuboid with a half-sphere is best shape for our design.

## VI. RESULTS AND OBSERVATIONS

### Results table

Prototype vs. Values	Cushion pressure (Pa)	Escape velocity (m/s)	Volume flow of air required (m <sup>3</sup> /s)	Thrust force (N)	Drag force (N)
Wooden	33.984	7.654	0.236	2.096	0.3589
3d printed with PLA	46.96	8.998	0.5945	6.2	1.239

Table No: 1. Calculated values & results

These are the values that we got after the completion of testing of the two prototypes, the values are calculated accurately and separately under similar conditions for both of the prototypes. These should be the values of parameters under best running conditions.

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 8, Issue 5, May 2019

### Observation table

Body material	Durability	Light weight	Ease of manufacturing	Steering	Braking	Portability
Poly lactic acid (PLA) [3D printed]	Less durability	Very low weight	Little skill required in design, production is easy	A little bit practice required for correct steering	Light weight and high speed takes more time for brake to work	Easily portable
Wooden made	Highly durability	Heavy weight	Manufacturing required more effort	High weight more friction ease of steering	Heavy weight on skirt makes braking effective	Low portability

Table No: 2. Materials & Design vs.Properties of Hull

These are the property changes that we observed during experimenting with the two material designs during the testing process

Skirt material	Durability	Light weight	Cost of manufacturing	Ease of making	Steering	Brake
Rubber	High	Poor	High	Poor	High	High
Canvas (cotton)	Poor	Average	Good	Average	Average	Good
Canvas synthetic	Good	Average	Good	Average	Average	Good
Nylon + PVC	Good	Good	Poor	Good	Poor	Good
Rubber + HDPE	Good	Average	Good	Good	Good	Average

Table No: 2. Material vs. Properties of skirt

The changes in skirt material we made gave us the different behaviour in properties of the skirt and the skirts are compared with reference to both of the prototypes and these observations are taken down

Skirt type	Durable	Ease of Making	Ease of repair	Replacement required	Power required	Draw backs
Bag	Good	High	Poor	Poor	High	High
Bag and segment combined	High	Poor	High	Good	Poor	Less

Table No: 3. Skirt type vs. Properties.

This table shows the different designs of skirts tested and their properties, these properties are by considering all the different skirt materials and on the tests done on both prototypes.

# International Journal of Innovative Research in Science, Engineering and Technology

*(A High Impact Factor, Monthly, Peer Reviewed Journal)*

Visit: [www.ijirset.com](http://www.ijirset.com)

**Vol. 8, Issue 5, May 2019**

## VII. CONCLUSION

The Air cushion vehicle has been designed and working, hovering with a consistent lift and moving across all the obstacle with ease. The basic craft made with wood was durable and good in braking but less efficient in forward movement with a low lift, the one made with PLA (3D printed) is less durable but was ease in steering and achieved a high lift and good speed

The skirt is made with different material and is attached to the Air cushion vehicle hull and tested with two different designs and different material performed well in different terrain and exhibit good result in different areas as steering, braking, durability, skirt material got easily damaged under wooden prototype but in PLA prototype skirt lasted long enough for different rides and tests.

## REFERENCES

1. Amith Tiwari M.Tech (Production engineering), Scholar, Pacific University Udaipur Rajasthan, INDIA, International Journal of Research - Granthalayah to Study and Fabrication of Air cushion Vehicle, Vol.3(Iss.3):March,2015
2. Okafor, B.E. Department of Mechanical Engineering, Fed. University of Technology., Owerri-Nigeria. 276 Development of a Hovercraft Prototype, International Journal of Engineering and Technology Volume 3 No. 3, March, 2013 ISSN: 2049-3444 © 2013 – IJET Publications UK.
3. G.Kishan, M B.V.S Rao, P. Ravinder Reddy, N.V.Srinivasulu CBIT, Hyderabad India. Structural Analysis of Dyneema-Epoxy Based Hovercraft Hull Using Finite Element Method.ird papers ISSN (Print) : 2321-5747, Volume-4, Issue-3,2016.
4. S.V. Uma Maheswara Rao-1, V.S. Surya Prakash-2 1, 2 (Professor, M.E Student, Department of Marine Engineering, AUCE (A), Visakhapatnam INDIA. Development of integrated air cushion vehicle. International Journal Of Modern Engineering Research (IJMER) | IJMER | ISSN: 2249-6645 Vol. 4 | Iss. 5| May. 2014 | 21 |
5. Mantle, P. J., "Air Cushion Craft Development", David W. Taylor Naval Ship Research and Development Center, Bethesda, Maryland, DTNSRDC-80/012,1980.
6. Doctors, L.J., "Nonlinear Motion of an Air-Cushion Vehicle over Waves," Journal of Hydronautics, Vol. 9, No. 2, April 1975, pp. 44-57.
7. A. K. Amiruddin, S. M. Sapuan and A. A. Jaafar, "Development of a hovercraft prototype with an aluminium hull base", International Journal of the Physical Sciences Vol. 6(17), pp. 4185-4194, 2 September, 2011. ISSN 1992 -1950