Design and Fabrication of Hovercraft

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ABSTRACT

Hovercrafts are vehicles that are able to glide over a relatively smooth surface by levitating upon air pockets or air cushion. This ability negotiates diverse terrain from land, water or marshy lands for transport, rescue and military operations. The design process is quite similar to that of boat and aircraft. Detail analysis has been done in accordance with standard requirements applicable in the air cushion model. Use of two lift engines have been made to obtain stable lift whereas dimmerstat controlled motor is used for thrust fan. Our attempt was to study the design characteristics and working principle of the hovercraft, and use standard calculations to determine the lift forces required and power. The total study process is concluded with mention of details for the constituent parts, which will be ascertained further by calculations from standard formulae. When the average person thinks of hovercraft, they think of huge vehicle that makes lot of noise. This statement is partly true and partly false, as you'll see it yourself when further study is presented to you.

Keywords: Hovercraft ,Lift Engine ,Thrust Fan.

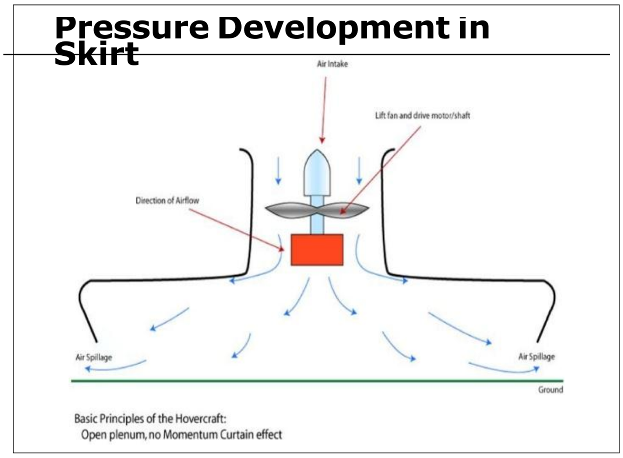
I. INTRODUCTION

A hovercraft, also known as an air-cushion vehicle or ACV, is a craft capable of traveling over land, water, mud or ice and other surfaces both at speed and when stationary. Hovercrafts are hybrid vessels operated by a pilot as an aircraft rather than a captain as a marine vessel. Hovercraft use blowers to produce a large volume of air below the hull that is slightly above atmospheric pressure. The pressure difference between the higher pressure air below the hull and lower pressure ambient air above it produces lift, which causes the hull to float above the running surface. For stability reasons, the air is typically blown through slots or holes around the outside of a disk or oval shaped platform, giving most hovercraft a characteristic rounded rectangle shape. Typically this cushion is contained within a flexible "skirt", which allows the vehicle to travel over small obstructions without damage. Vehicles designed to travel close to but above ground or water.

These vehicles are supported in various ways. Some of them have a specially designed wing that will lift them just off the surface over which they travel when they have reached a sufficient horizontal speed (the ground effect). Hovercrafts are usually supported by fans that force air down under the vehicle to create lift, Air propellers, water propellers, or water jets usually provide forward propulsion. Air-cushion vehicles can attain higher speeds than can either ships or most land vehicles and use much less power than helicopters of the same weight. Air-cushion suspension has also been applied to other forms of transportation, in particular trains, such as the French Aero train and the British hover train. Hovercraft is a transportation vehicle that rides slightly above the earth's surface. The air is continuously forced under the vehicle by a fan, generating the cushion that greatly reduces friction between the moving vehicle and surface. The air is delivered through ducts and injected at the periphery of the vehicle in a downward and inward direction. This type of vehicle can equally ride over ice, water, marsh, or relatively level land.

II. PRINCIPLE OF OPERATION

The hovercraft floats above the ground surface on a cushion of air supplied by the lift fan. The air cushion makes the hovercraft essentially frictionless. Air is blown into the skirt through a hole by the blower as shown in Figure 1. The skirt inflates and the increasing air pressure acts on the base of the hull thereby pushing up (lifting) the unit. Small holes made underneath the skirt prevent it from bursting and provide the cushion of air needed. A little effort on the hovercraft propels it in the direction of the push. Figure below shows how pressure is developed in the skirt. As soon as the assembly floats, a blower incorporated in the thrust engine blows air backwards which provides an equal reaction that causes the vehicle to move forward. Little power is needed as the air cushion has drastically reduced friction. Steering effect is achieved by mounting rudders in the airflow from the blower or propeller. A change in direction of the rudders changes the direction of air flow thereby resulting in a change in direction of the vehicle. This is achieved by connecting wire cables and pulleys to a handle. When the handle is pushed it changes the direction of the rudders.



III. MAIN COMPONENTS

Frame:

It is the basic structure on which the Hovercraft floats when the engine is stopped while moving over water or land. It supports the whole weight of the craft. It includes the craft floor, side panels, forward and aft panels till the top skirt attachment line. The lower hull.

Need to have adequate size for supporting the total weight of the craft and payload.

Must be strong enough to support craft off cushion (on landing pads).

Have enough freeboard to support craft in displacement mode on water.

Must be watertight and as smooth as possible.

The lower hull can be built by all boat building materials, from simple ply to very complicated composite panels.

Skirt:

The skirt is a shaped, flexible strip fitted below the bottom edges of the plenum chamber slot. As the hovercraft lifts, the skirt extends below it to retain a much deeper cushion of air. The development of the skirt enables a hovercraft to maintain its normal operating speed through large waves and also allows it to pass over rocks, ridges and gullies. The skirt of a hovercraft is one of its most designed sensitive parts. The design must be just right or it may result in uncomfortable ride for passengers or damage to the craft and the skirt. Also, excessive wear of the skirt can occur if its edges are flapping up and down on the surface of the water or on land. The skirt is taken to hold the air pressure which is generated inside the base or downside of the platform. The skirt is mounted on the base by the nail or glue or other thing which can bear the pressure of air.

Lift system:

It is fitted to the primary structure of the hovercraft. The air is pumped under the craft between the skirt spaces to produce a cushion of air in order to accelerate a hovercraft in a vertical direction. Propeller is designed to be most efficient in open air but are not efficient in application when an air backpressure is need to be applied as they rotate. Because of this the lifting of most of the Hovercraft model uses what is known as a centrifugal fan or blowers. Two blowers are used of capacity 2 HP and 3 HP. When the assembly is rotated at high speed, air is sucked into the center hole in the fan and the slots forces it out at the edges. The advantages of the fan are twofold. They operate efficiently in an environment when back pressure is high and they moves large volume of air for a given rotational speed than a propeller with the same speed and power input.

Thrust Fan:

It is used to obtain the forward motion of the craft. It is fitted to the top of the Craft and is powered by a petrol/diesel engine. The fan is supposed to overcome the force of the entire craft in order to propel it in forward direction. It can come with minimum of two blades and can increase up to 8- 10 blades in standard fans. In our case we are using dimmerstat controlled motor for the rotation of the fan.

Rudders (Steering System):

Rudders are plate like thick sheets of metal or wood which are used for changing the direction of hovercraft by hydraulic systems or by a suitable steering mechanism. These are attached at rear end of thrust fan. On moving of the rudders in either direction, there is a corresponding change in direction of hovercraft. They can also be used for slowing down the speed of hovercraft by tuning them 180 degrees (Inward) thus causing the resistance for forward motion.

Engine:

Engine is the device which powers the blower to blow the air beneath the hull or frame. Two petrol engines of capacity 2HP and 3HP were connected to the blowers by their output shaft. Engine is powered by petrol/diesel as a fuel (input). The lift engine coupled with the blower provides necessary air flow in downward direction causing the pressure to rise in skirt and form the air cushion. It is necessary for the engines to run at max RPM to maintain the required flow rate.

Specifications:

Length – 2.0828 m
Base width – 1.2192
Surface Area (As) = 1.879 m2
Perimeter – 5.9325 m
Air cushion height – 2 cm

Lift Calculations:

Gross weight = Fan Unit + 2 Engines + 2 Blowers + Motor + Hull + Pilot + Steering Mechanism = 180 kg

Force = Weight * 9.81 m2/s
= 1765.8 N

Exit Pressure (Pe) = Force/ As (i)
= 1765.8/1.879 = 939.75 N/m2

Area of Air = Perimeter * Air cushion height (ii)
Cushion (Ac) =5.9325 * 0.02 = 0.1186 m2

Escape Velocity (Ve) = Dc * √ (2 Pe/ ρ) (iii)
= 0.53 * √ (2*939.75/1.225) = 20.76 m/s
(Where, Dc – Coefficient of discharge
ρ – Density of Air = 1.225kg/m3)

Discharge (Q) = Ve * Ac (iv)
=20.76 * 0.1186 = 2.462 m3/s

Total Power required (P) = (Q * Pe) / (η * 1000) (v)
= (2.462 * 939.75) / (0.7 * 1000) = 3.305 KW
= 3.305/746 = 4.43 HP

Position of Engines/Blowers

Taking moment about CG,
(FB * 30) – (* 20) = 0

Therefore, FB = 1.5 FA

Thus, for proper balancing of hovercraft the power generated by Engine B (at the base) should be equal to 1.5 times the power of Engine A (at apex)

For constant pressure,
Power is directly proportional to Discharge (Q)…from (v)
Therefore, QB = 1.5 QA
Total discharge (Q) = 2.462 m3/s
= QA + QB
= 2.5 QA
Thus QA = 2.462/2.5 =0.9848 m3/s
QB = 1.5 QA = 1.4772 m3/s

Therefore,
Power of Engine A
PA = (QA * Pe) / (η * 1000)
= 1.773 HP ≈ 2 HP (Standard Value)

Power of Engine B
PB= (QB * Pe) / (η * 1000)
= 2.662 HP ≈ 3 HP (Standard Value)

Thrust Calculations:

24 inch diameter, Type 3, 4 blades in 8-blade hub, 3600 rpm, at stated blade pitch produces:

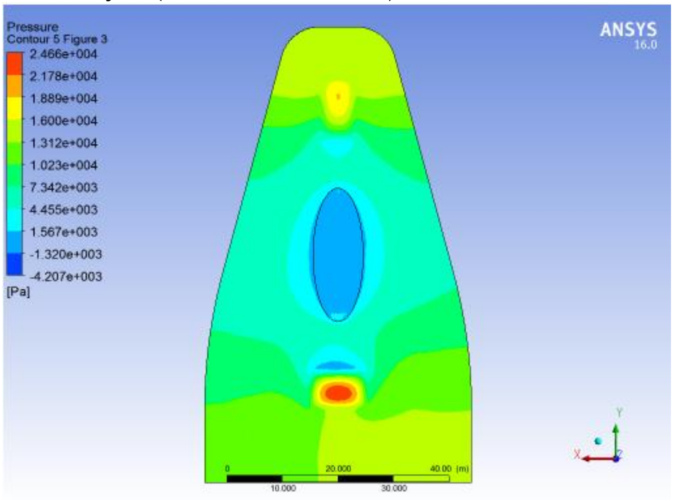
25 degrees, 9480 CFM, 17.5 pounds, using 3.5 HP
30 degrees, 12,000 CFM, 23 pounds, using 5.5 HP
35 degrees, 15,400 CFM, 33 pounds, using 8 HP
40 degrees, 17,00 CFM, 39 pounds, using 10.5 HP
45 degrees, 20,100 CFM, 50 pounds, using 15 HP
50 degrees, 21,800 CFM, 58 pounds, using 18 HP

Thrust Force = Lift force/2
= 1765.8 / 2 = 882.9 N

Flowrate = 268.4437 m3/min
= 4.466 m3/s

For overcoming above thrust force, the 1st fan with indicated specifications can be used.

CFD analysis (Pressure Distribution)



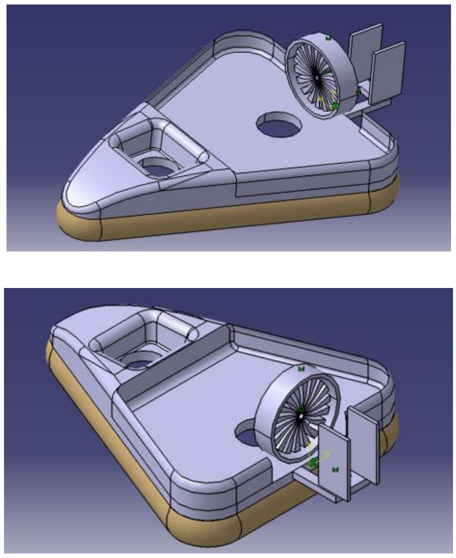
Future Scope

To develop lighter hovercraft by using best materials for better efficiency

Make more research on hovercraft background and construction.

To find appropriate position and number of lift engines for better flow and pressure distribution.

To recognize all hovercraft applications and limitations and also to define a hovercraft as per classification.



Model of Hovercraft

IV. CONCLUSION

Hovercrafts are generally simple mechanisms in theory. One must take under consideration the weight and the shape of each component in order to avoid problems such as instability and dysfunction. This is a marvelous machine which greatly cuts down the friction which in turn helps it to attain greater speed and more stability. Varieties of problems and factors have to be taken into account in designing and constructing a hovercraft.

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