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Portable Hovercraft Concept 3.0

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Abstract : Hovercraft types of vehicles that are lifted above the surface of land or water by an air cushion created by downward-directed fans. It is also classified as Air Cushioned Vehicles (ACV) owing to their capacity to travel through a cushion or skirt filled with air that causes the board to hover above the ground. This concept utilize a single propeller that can provide sufficient lift and also propel the hovercraft. There is fivemain parts of this portable hovercraft which is chassis, fan, duct, skirt, and engine. Aluminum Alloy 6061 was chosen as its chassis. Umbrella mechanisms were used to make the portable chassis. It is easy to fold and unfold. Next, the propeller is made from wood and connected directly to the engine, without the need for belts or chains for power transmission. The 5-blade design with 35° pitching angle is used to propel forward and lift the hovercraft. Fabric skirting from neoprene-coated nylon was used to contain air laterally and is shaped like an open tube with very low air pressure coming from the propeller. Neoprene-coated nylon was chosen as skirting material. It seems that there is a resilience from being scratch or tears. To increase the propeller's efficiency, a fan with a non-rotating nozzle called a duct was constructed from the fiber. Additionally, it serves as a replacement for the rudder, resulting in increased thrust in a more compact package. A 6.5 hp single cylinder four-stroke petrol engine was selected to power this hovercraft.

Keywords : Hovercraft, Portable Vehicle , Amphibious Vehicle, Motion

1. Introduction

Hovercraft is a kind of vehicle categorized as an Air Cushioned Vehicle (ACV), which is uplifted by an air cushion and pushed forward, overland, water, and the paludal zone [1]. Hovercraft make use

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of blowers to generate a huge volume of air underneath the hull, or an air cushion slightly above atmospheric pressure. The skirt formed a pocket for the compressed air that provides the lift necessary for hovercraft to operate. The Saunders-Roe SR.N1 through SR.N6 watercraft, built on the Isle of Wight and deployed by the United Kingdom's combined forces, was the first hovercraft invented [2].

Due to the Monsoon season, floods are a common natural catastrophe in Malaysia, occurring almost every year. Peninsular Malaysia's east coast is particularly prone to flooding during the northeast season, which runs from October to March [3]. This portable hovercraft may potentially help a huge number of people in dire need. This product was designed to be readily stored; it took up the same amount of space as a motorbike. This vehicle may be used in lieu of a motorboat, allowing everyone to own and store one.

2. Materials and Methods

In hovercraft development, a careful selection of material was needed in order for the hovercraft fully operational as expected. As a result, several parameters must be considered during the development process. Among the constraint of the material of the body chassis is low density, suitable tensile strength and durability to support the hovercraft and suitable for outdoor and indoor usage. Next, the material constraint of the propeller is low density, workability and high strength qualities like elastic but not excessively hard. Lastly, the constraint of the skirting material is perfect airtightness suitable for hovercraft skirting development, fireproof, acid resistance, UV resistance, water and radiation insulation.

2.1. Properties of Materials

2.1.1. Hovercraft's Chassis

The chassis of the hovercraft is made from Aluminum Alloy 6061 that has a tensile strength of 780 Mpa. The Aluminum Alloy 6061 was chosen as the chassis for this hovercraft. The mechanical properties of Aluminum Alloy 6061 is low density, strong build and suitable for outdoor usage. In addition, Aluminum Alloy is accessible in other words can be easily obtained in most hardware shops.

2.1.2. Hovercraft's Propeller

The hovercraft's propeller that is made of Yellow Birch wood composed of several distinct layers, was chosen due to its low density, ease of work and high strength features such as elastic and robust but not exceptionally hard for the propeller development by using wood lamination that minimizes propeller warp tendency. Typically, hovercraft propellers are ducted propellers. Hovercraft propellers are produced in aviation, with GE's MT-propellers, Hoffman and DowtyRotol generating some of the more popular and well-proven versions [4].

2.1.3. Skirting

The skirting of the hovercraft is made from Neoprene coated nylon. Neoprene was selected as the preferred fabric due to its perfect airtightness which is suitable for the development of the skirting of the hovercraft and is widely used in the manufacture of inflatable structures of all sorts. Besides that, Neoprene coated nylon has been tested for fireproofed, acid resistance, UV resistance, water-resistance and isolation from radiation. It also has a non-skid surface to keep the hovercraft from skidding away while in motion. While maintaining skirt form under operational conditions necessitates a reasonably high internal skirt pressure, this pressure can also result in a significant rough water drag [5].

2.2 Equations

2.2.1The theoretical power requirement

Lift Area and Perimeter

$$Area = \pi r^2 \quad \textbf{Eq. 1}$$

$$= \pi(1.1)^2$$

$$= 3.6\, m/\, 12.47\, ft$$

$$Perimeter = 6.9\, m/\, 22.64\, ft \quad \textbf{Eq. 2}$$

The 22.64 ft perimeter will not include the outside hull slope. A perimeter of 90 percent was utilized to take into consideration the wasted space since the hover gap centerline is between the slope of the outer hull.

$$\text{Perimeter} = 22.64\ \text{ft x } 90\% = 20.376\ \text{ft} \quad \textbf{Eq. 3}$$

Hover Gap

Hovercraft hover gaps usually range from 1/2 to 1/1. At least 1⁄2 is necessary for proper lubrication under the hull, which reduces skirt scraping.

$$\frac{3}{4}\text{x}\frac{1\text{ft}}{22\text{in}} = 0.0625\ \text{ft} \quad \textbf{Eq. 4}$$

$$Hovergap\ area = 0.0625\ x\ 20.376 = 1.2735\ ft^2$$

Cushion Air Pressure

$$Lift\ area\ =\ 12.47 ft\ x\ 90\%\ =\ 11.223\ ft^2$$

Estimated total weight (with passenger) = 110kg/ 242.5 lb

$$\frac{242.51}{11.223} x \frac{1ft^2}{144in^2} = 0.1500\ Psi$$

Air velocity

$$Air\ velocity\ = \frac{0.150\ x\ 115.3}{0.109} = 158.67\ \text{m/s} \quad \textbf{Eq. 5}$$

$$Actual\ air\ velocity = 158.67\ x\ 60\% = 95.196\ \text{m/s}$$

3. Results and Discussion

The concept of portable hovercraft was able to function as targeted from the objective. The performance of the hovercraft's compartments adapts well with the hovercraft's specifications in terms of strength, durability, and low density. This project analyses some major factors that have a significant role to the performance, which is the hovercraft chassis material selection, mechanical properties of chassis material, thrust, power requirement for static lift and portable hovercraft design.

3.1 The Chassis of the Hovercraft

3.1.1 Weight Estimation

There are two suggestions materials that met the requirement for this part and that is aluminum alloy and stainless steel 304. The chosen material must have a low density due to the objective of this project is portable design. This project was thoroughly examined to determine the most suitable material for the hovercraft's body chassis.

Density of aluminum alloy 6061, ρ = $2700\ kgm^{-3}$ [6]

Volume of body chassis, m = volume of lower chassis + volume of upper chassis **Eq. 6**

$$= [(1\ m\ x\ 0.03\ m\ x\ 0.015\ m) + (0.9465\ m\ x\ 0.3\ m\ x\ 0.015\ m)]$$

$$= 0.0475\ m^3$$

$$\rho = \frac{m}{v}\ ,\qquad m = \rho v \ldots \qquad \textbf{Eq. 7}$$

$$m = 2700\ kgm^{-3}\ x\ 0.0475\ m^3$$

m = 128.25kg assuming full material without holes

Density formula has been used to calculate the total mass of the body chassis by determined the density of aluminum alloy 6061 ($2700\ kgm^{-3}$) and total volume of body chassis which is the volume of upper chassis and lower chassis parts. Based on **Figure 1** the lower chassis has 1.0 m length, 0.03 m width and 0.015 m height while the upper chassis has 0.9465 m length, 0.3 m widths and 0.015 m height.

Therefore, it is stated that using aluminum alloy 6061 is considered the best material for the hovercraft's body due to its low density and capability to hold the hovercraft. By the calculation above, this result proves that aluminum alloy 6061 is most suitable for body chassis material due to the low density of the material.

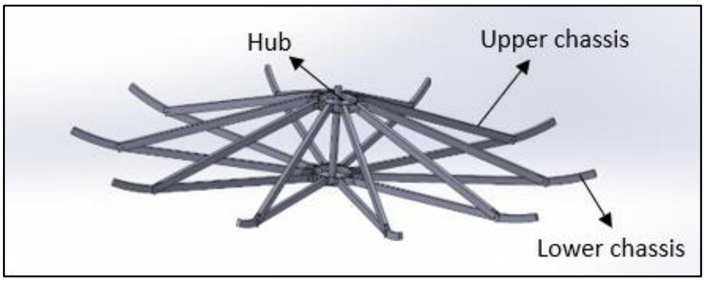

Figure 1: Full hovercraft body chassis

3.1.2 Mechanical Properties

The type of metal selected for the body chassis has a significant impact on how long it will last in any type of weather. Aluminum alloy 6061 and stainless steel 304 are two of the best metals to use in this part of the project but only one material will be selected. The metal used to make hovercrafts has been compared to a new type of metal that will be used. The metal will be more durable and stronger to hold the hovercraft in place. **Table 1** compares both metals to prove which one is the suitable material for meet the objective.

Table 1: Comparison between aluminum alloy 6061 and stainless steel 304 [6]

Properties	Aluminum Alloy 6061	Stainless Steel 304
Density (kg/m)	2700	8000
Elastic modulus (Gpa)	68.9	210
Poisson' ratio	0.3	0.3
Tensile strength (MPa)	310	515

Ultimate strength (MPa)	275	360
Maximum allowable stress (MPa)	93.75	176.25

The tensile and ultimate strength of aluminum alloy 6061 is lowered compared with Stainless Steel 304. On the other hand, Aluminum alloy 6061's density almost one third compared with Stainless steel 304 If the material selected is high density, the possibilities for hovercraft to lift is low. This is the main reason why aluminum has been selected as the most suitable material.

3.2 Thrust

One of the most essential factors in hovercraft development is thrust. A hovercraft may sail at a reasonably high speed on the surface of the water or on the land due to the thrust value of an air propeller installed on the hovercraft [7].

$$T = (Rpm_{prop} \text{ x } 0.0254 \text{ x } pitch \text{ x } \frac{1min}{60\text{sec}})^2 \qquad \textbf{Eq. 8}$$

Hovercrafts can travel at a high speed on the surface of the water or on the ground. The thrust generated must always be 2 times the entire mass exerted to move the hovercraft. The force and thrust relationship must be directly proportionate in every hovercraft design.

$$T = (3600\, rpm \text{ x } 0.0254 \text{ x } 35inch \text{ x } \frac{1min}{60sec})^2$$
$$T = 2845.16\, N$$

To estimate t$otal$ $weig$ht of the hovercraft:

50 kg $passenger$ + 20 kg chassis + 15 kg engine + 8 kg $skirt$ + 7 kg propeller + 10 kg air duct = 110kg

To move the hovercraft, the minimum thrust calculated was 2845.16 N, which is somewhat less than the entire mass. Supposedly, this thrust value can carry the total weight of hovercraft 110 kg or 1078.73 N which is below the thrust value. The chosen engine has set aside some of its power for propulsion.

3.3 Theoretical Power Requirement for Static Lift

Calculating the necessary power for static lift result. If we assume that all of the air flowing through the propeller flows into the air cushion and apply the Bernoulli equations to estimate air flow while ignoring frictional losses [8], For a variety of reasons, including its simplicity and ability to provide valuable insight into the balance between pressure, velocity, and elevation, the Air Velocity equation is very helpful. The following formula:

Minimum Lift Air Volume Requirement

Actual air velocity = 95.196ft/s
$Hover\ gap_{\ area} = 1.2735 ft^2$
$95.196 fts^{-1}\ x\ 1.2735 ft^2 = 121.23 ft^3 s^{-1}$ = 7273.8 ft^3/minute

Total cubic feet per minute (CFM) will create around 30,000 normal cruising speeds. Since only 30% has been sent to the lift system, only 9000 CFMs at typical cruising speed will be created [9]. 6000 CFM will still produce a suitable 1⁄2 hover gap for safety issues [5].

Theoretical horsepower requirement

$$120.89 ft^3\ s^{-1} x\ 0.150 lbsin^2 x \frac{144in^2}{1ft^2} = 2611.224 ftlbs^{-1}$$

$$\frac{2611.224}{550} = 4.7\ hp$$

The minimum power required is 4.7 hp, however the project has put aside a 6.5 hp engine. Based on the vehicle's size and mass, it is feasible to determine the volumetric flow rate required by a hovercraft fan in order for the vehicle to hover using Air Velocity equation [10]. In the case of incompressible flow, we may determine the amount of power needed to pressurize the cushion at a given clearance height for a given weight load on a certain area deck by multiplying the mass flow rate of the leaving air by the kinetic energy of the outgoing air.

3.4 Portable Hovercraft Design

This design of portable hovercraft makes use of the concept of lightness, which is a large surface area, to reduce the amount of pressing factor that is applied, Bernoulli's principle of pressing factor, and the concept of static thrust. The static thrust that has been mentioned complies with the law of hovercraft development, and a hovercraft engineer or manufacturer needs to understand this rule before constructing a hovercraft. This is due to the fact that hovercrafts utilize an air cushion, and therefore need a sufficient quantity of air to be contained inside the air cushion. 3D computer-aided design (CAD) has been used to create this prototype design of hovercraft as shown in **Figure 2**. This is the place where all the design work is completed. Starting with a sketch, then design corrections, and finally the finished design.

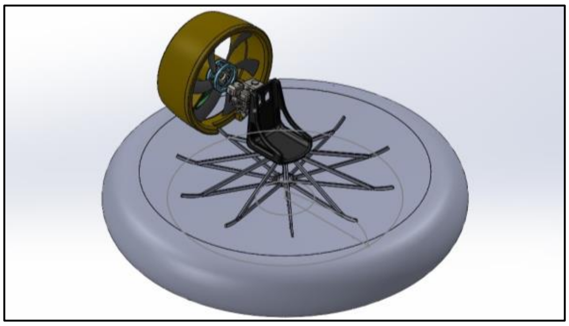

Figure 2: The design of portable hovercraft

This design can be easily assembled for any first-time user every detail of the design were made to make it user-friendly which is the body chassis used umbrella mechanism. The craft of the portable hovercraft can be broken down into five pieces: body chassis, skirt, 1 engine with propellers and a seat. Every craft can be perfectly fit into the boot of a reasonable-sized family car.

4. Conclusion

In conclusion, the power from the engine is enough to produce a thrust to moving forward and lift the hovercraft. The engine with 6.5 horsepower can produce up to 3600 rpm. The minimum power required is 4.7 horsepower.

The thrust produced from the engine to the fan is one of the most essential factors in hovercraft. The propeller with 5 blade and 35° pitch angle that was made from wood is suitable to generate trust. The accelerating duct increases the propeller's inflow velocity and efficiency. The force and thrust relationship directly proportionate in every hovercraft design with value 2845.16 N.

The total weight of hovercraft with a passenger is 110 kg or 1078.73 N. To travel at high speed on the surface of the water and on the ground, the thrust must generate 2 times the entire mass. The minimum thrust calculated was 2845.1 N, which is somewhat less than the entire mass. The design of this portable vehicle is portable enough because of the chassis of the hovercraft that can be folded and unfold easily. The whole hovercraft also can be loaded is the car boot. The umbrella mechanism of the chassis is the main part to make it look very portable. Its patented structure can be folded and install without tools in a few minutes by one person. All the component is just plugged and play looks like. Safety is one of the most important part of to the design of any project.

Generally, four-stroke engines are much quieter than the two-stroke engines used by many manufacturers. Low revving four-stroke engines operate quietly and smoothly. As a result, it is possible to produce less vibration. External vibrations from existing hovercraft are dominated by those generated by the propeller, and emphasis is given to the fact that real measurements demonstrate that this noise is significantly larger than theoretical projections would anticipate. To minimize vibration, it is critical to use a propeller made of wood because it is a viscoelastic material and the more blades it has, the less vibration it produces [11].

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