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DESIGN OF AN ELECTRIC HOVERCRAFT

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Abstract

Electric Hovercraft is an amphibious vehicle that can move with equal ease on both land and water and any other terrain. It is also known as air cushion vehicle. The development of hovercraft has been outstandingly faster than that of any other mode of transport. The aim of this paper is to design one man electric hovercraft. Moreover, the purpose of presenting this paper is to implement new ideas and concepts to make design safer, most effective and importantly more environmentally friendly. The design of Hovercraft applies two DC motors to lift and thrust the craft, better aerodynamically design. By using electric motor, the lift system can be shutoff as it leaves the ground. It is design to test motor configuration, electronics and efficiency and battery technology. In the future the craft will again be upgraded with higher battery output pack and more heavily loaded motors.

I. Introduction

Hovercraft is an amphibious craft that can move on both land, water, mud, ice and other smooth surfaces. It is also known as air cushion vehicle, the air continuously forced under the vehicle by fan, generating the cushion that greatly reduces the friction between the moving vehicle and surface which allow to vehicle to float above the surface. Hovercraft needs battery

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power to produce an air current that will push it forward. Hovercraft is used for transportation of passengers and goods, sporting activities, rescue and military operations. Hovercraft provided a faster and smooth run compared with other marine vehicles and also a good performance on the rough surface as well. Hovercraft have no underwater pressure signature and have no impact on marine life. The concept was first proposed by John Thornycroft in 1870s but working model produced by Sir Christopher Cockerell in 1955s.

II. Literature

(i) Sir Christopher Cockrell (1952) (British Engineering) – He invented the hovercraft. Developed the hovercraft principle further and got his idea patented in 1955. With diligent work he was able to bring his idea to reality with the first commercial hovercraft in 1959.

(ii) Susanna B. Blackwell and Charles R. Greene Jr (2005)- "Under water and in air sounds from a small Hovercraft" In this paper they worked on Underwater and in-air recordings were made from a boat anchored. The hovercraft produced sound at a wide range of frequencies.

(iii) An Wei, Ao Chen-yang and Liu Qiang (2005)- "Research on simulation on lift and propulsion control for hovercraft" In this paper they research on simulation of lift and propulsion control for hovercraft, the dynamic characteristics of whole system with the controller is excellent. This indicates the advantage of serial PID control system in the hovercraft fixed rotation speed control.

(iv) Zhang Zong-ke (2006)- "Testing and theory study of hovercraft model skirt vibration platform" The development of vibrations testing platform project for hovercraft model skirt, the testing system has been developed by using the LabVIEW language, which was used to measure the response frequencies of heave, pitch and roll of a medium sized hovercraft.

(v) Wei An, Xin-Chuan Chen, Chen-yang Ao and Huaqing Chen (2007)- "Simulation Research on the power system of hovercraft based on MATLAB" The simulation of the power system is the important means to study the dynamic performance of the power system of hovercraft. The simulation model is established based on MATLAB. The research results can offer conferences to the design and test of hovercraft.

(vi) Christopher Sconyers (2013) - "Diagnosis of fault modes of hovercraft system" They introduce a methodology for the design testing an assessment of incipient failure detection technique for failing system of critical engineered systems masked or hidden by feedback control loops. They describe briefly in this paper an autonomous hovercraft as the test prototype.

(vii) Amit Tiwari (2015) - "To study and fabrication of air cushion vehicle" In this paper he introduces hovercraft model working on the laws of buoyancy, Archimedes principle and newton third law. Hovercraft is manually operated and work on engine.

(viii) Kamran Ahmed Khan, Salman Ali Khan and Mohammad Usman (2016)- "Design and fabrication of remote-controlled hovercraft" In this paper, they design a hovercraft using lift system and spy camera and two BLDC motor interfaced with a microcontroller to achieve desired functionality which can be controlled by a remote.

III. Components and Design

1. Lower Hull-It is the basic structure on which the Hovercraft floats when the engine is stopped while moving over water. It supports the whole weight of the craft.

2. Skirts-They are air bags inflated by air are fitted around the perimeter of the craft hold air under the craft and thus upon a cushion of air. It enables to obtain greater Hover height. The material used is rib stop nylon.

3. Lift Fan-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. The operating efficiently in an environment when back pressure is high and they moves large volume of air for a given rotational speed.

4. Propeller-It is used to obtain the forward motion of the craft and fitted to the top of the craft and is powered by a dc motor. The fan is supposed to overcome the force of the entire craft in order to propel it in forward direction.

5. Rudders-Rudders are plate like thick sheets of metal or wood which are used for changing the direction of hovercraft 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 those 180 degrees thus causing the resistance for forward motion.

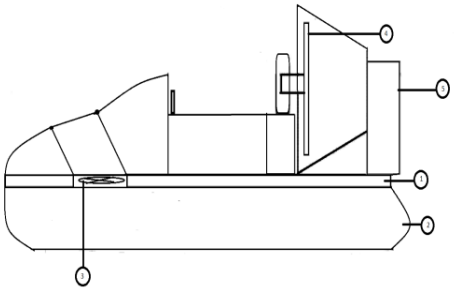

Figure 1. Hovecraft Model.

IV. Working Principle

The hovercraft work on the principle to lift the craft by a cushion of air, using propellers. The air cushion makes hovercraft frictionless. The idea of providing the vehicle on a cushion of air beneath the boat developed from the idea to increase the speed of boat. The air beneath the hull would lubricate the surface and reduce the water drag on craft and so increasing its speed through water. The air sucked by large lifting fans which are fitted to the primary structure of the craft. They are powered by DC Motors. As soon as the assembly floats, a propeller fitted in the thrust motor blows air backward which provides unequal reaction that causes the vehicle move forward. Steering effect is achieved by mounting rudders in the air flow from the propeller. As the direction of the rudder change the air flow direction changes which result in change in direction of hovercraft. Also the direction of craft can be change by shifting the weight of driver nearer to any of the four side of the deck.

V. Calculation

Length = 2.2 m

Width = 1.1 m

Gross Mass = Craft weight + Pilot weight

= 200kg

Area = Length × width= 2.42m^2

Cushion Pressure = Gross Weight/Cushion Area

Gross Weight = gross mass × gravitational force

=1962N (Lift force)

Cushion Pressure = Gross weight/Area

Cushion pressure = 1962/2.42

=810.74Pa

Volume rate of cushion = Total Hovergap Area × velocity of air

Total hovergap area = Lift Parameter × Airgap

Lift Parameter = (2×length) + (2×width) = 6.6m

Air gap:-It is the space between hovercraft and the ground which is equal to 0.008m.

Total Hovergap Area = 6.6×0.008

=0.0528m^2

Velocity of Air = Dc × (2×Pe/Density) ½

Dc (Coefficient of discharge) = 0.53,

Pe (exitt Pressure) = Gross weight/ S.A=1154.11N/m^2,

Density = 1.225kg/m^3

Velocity = 23m/s

Volume rate of cushion = 0.0528×23

=1.214m^3/s

Coefficient Fraction of fan = 0.593

Power = cushion pressure × volume rate of cushion

= (810.74×1.214) ×10^{-3}/0.593

=1.659kw

Power of lift motor = 1.65kw

Thrust force = Lift force / 2

= 981N

Power of thrust motor = 1.5kw

VI. Conclusion

This is a unique type of hovercraft as no one has ever designed electric hovercraft in the past on large scale. The values for lift power and thrust power of motor is calculated and was found that the overall weight is reduced around 50kg. This resulted in increase in overall performance and aerodynamic stability of the craft as well reduction in emissions.

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