

Design and Fabrication of a Remote Controlled Hovercraft

Kamran Ahmed Khan¹, Salman Ali Khan², Mohd. Usman³, Yuvraj Singh Chib⁴, Loveneesh Talwar⁵

U.G. Student, Department of Electrical Engineering, YCET, Jammu, India¹⁻³

Assistant Professor, Department of Electrical Engineering, YCET, Jammu, India⁴⁻⁵

ABSTRACT: Hovercraft is a non wheeled vehicle which hovers over or moves across all types of surfaces including grass, mud, muskeg, sand, quicksand, water and ice very easily using high powered fans (propellers) and aerodynamic design. It is also called as Air Cushion (AC) Vehicle. Main Objective of this project work to be carried out is to design a Hovercraft using Lift System and Spy Camera which can be controlled by Remote and uses two high rpm BLDC motors interfaced with a Micro-Controller to achieve desired functionality. Moreover the purpose of presenting this paper is to implement new ideas and concepts to make design safer, cost effective, light in weight, more aerodynamically and importantly more environmental friendly. The motor which is below the hovercraft rotates at a very high RPM that allows it to generate a force enough to make it hover on the surface, whereas motor mounted behind it, help to push the hovercraft in forward direction. The movement of hovercraft is controlled through remote which send command to the micro-controller which generates pulse signals for the motor to be operated. A camera is also fitted on its top which records the surrounding activities and displays it on the screen.

KEYWORDS: RC-Hovercraft, BLDC (Brushless DC) Motors, Aerodynamic design, High-powered fans (Propellers), Wireless Camera, Remote Control.

I. INTRODUCTION

John Thornycroft proposed the first concept of hovercraft in the 1870s, but a working model was not produced until 1955, when Christopher Cockerell, a British engineer, solved problem of keeping the air cushion from escaping from under the vehicle, and formed Hovercraft Ltd. to manufacture prototypes. The first hovercraft was actually launched in the Soviet Union long before Cockerell's maiden voyage. Hovercraft is a vehicle which is capable of hover over any kind of surface like ground, water, mud or ice and other surfaces by creating a cushion of air below it. It operates by creating a cushion of high pressure air between the base plate of the craft and the surface below. There are two main principles in which hovercraft work: - Lift and Propulsion. Among two factors Lift is an important factor because it is that which allows the craft to ride on a cushion of air. This process begins by directing airflow under the craft. In order to accumulate the air under the air cushion, a skirt is required. The common skirt is known as a bag skirt. The skirt that we have is used is made up of Nylon. It covers the bottom of the base and has holes in it to for air to escape and push the craft off the ground. The more stable the skirt is, the slower the hovercraft will move. A fan or propeller is used to move the air for propulsion. The reason behind the craft to flow is the difference between the higher pressure air below the craft and lower pressure ambient air above it. The air is endlessly forced into the vehicle by a lifting fan connected to the motor, forming the cushion of air that greatly reduces friction between the moving vehicle and surface. Hovercrafts are usually supported by two fans (propeller) – one force air down under the vehicle to create lift where as the other fan help in the forward motion of craft.

The thrust force responsible for the forward motion of hovercraft in the horizontal direction is achieved with the help of a thrust fan mounted on fan duct on back of hovercraft. Since an air cushion vehicle does not have wheels, the forward movement is made through the driving activity, which is created by the use of a remote control device. Hovercraft attains a higher speed that than can either be attained by most ships or land vehicles.

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II. WORKING PRINCIPLE

Hovercraft works on the principle of lift and propulsion. The basic mechanism of a hovercraft is very simple: there are two BLDC (Brushless DC) motors that power both fans (propeller). The motor at centre have fan i.e. which is pointed downward is used to lift the craft. When this motor is operated, it creates the cushion of air in skirt and lifts the craft slightly above the ground. Once the craft is hovered or lifted or a cushion is formed, thrust must be created to move the hovercraft in a forward direction. So the second motor is fixed at the back side if the craft. When this motor operated, it makes the craft to move in forward direction. The movement of hovercraft is controlled by using Remote Control which sends command to the controller fixed on hovercraft. Micro-controller receives the command and sends the pulse signal to the brushless motors to run. When motor is started the hovercraft is lifted slightly above the ground due to the formation of air cushion. There is also fitted a camera which capture all the recordings around the craft where the craft move. These recordings are then displayed on the screen.

III. METHODOLOGY

ARCHIMEDES' PRINCIPLE OR THE LAW OF BUOYANCY

In order to lift the Hovercraft on water surface, the pressurized air must push against the surface of the water. This can be explained by Archimedes' Principle or the Law of Buoyancy which states the "When a body is immersed in fluid at rest, it experiences an upward force or buoyant force which is equal to the weight of the fluid displaced by the body". Archimedes' Principle says that a buoyant force will push the body upwards when the body is placed in the water, and the strength of the force will be equal to the weight of the water that the body pushed out of the way. The same thing happens with boats. When a boat is placed in water, part of the boat goes beneath the surface of the water and pushes the water out of the way. The boat floats in the water because the upward buoyant force is equal to the downward weight of the boat. In order to do calculations using this principle, we need to know the weight of a certain volume of water that is displaced, or the weight density of water.

NEWTON'S THIRD LAW

The third law states that "all forces exist in pairs: if one body (say X) experiences a force F_x on other body (say Y), then simultaneously the second body (i.e. Y) exerts a force F_y on first body (i.e. X) but in opposite direction and therefore, the two forces are equal and opposite: $F_x = -F_y$. The Newton third law describes the forces between two completely different bodies as forces of interaction, and therefore there is no such factor as a unidirectional force or a force that acts on just one body. This law is usually cited as the action-reaction law, with F_x as the "action" and F_y as the "reaction". The two forces are acting simultaneous, so it does not matter which force is termed as Action and which one as Reaction. The two forces are the part of the single interaction and, therefore no force exists without the other force. Hence, the two forces in Newton's third law are of similar type.

AERODYNAMICS

Aerodynamics is defined as the branch of fluid physics that studies the forces exerted by air or other gases in motion. Hovercraft works on aerodynamic principal as it float on cushion of air created by the air developed by propellers. This air formed beneath the hovercraft help to reduce the friction between the hovercraft and ground. This reduction on friction due to air cushion increases the speed as well as efficiency of hovercraft. For maximum efficiency, the aim is usually to design the shape of an object to produce a streamlined flow, with a minimum of turbulence in the moving air.

IV. CONSTRUCTION

The main focus of this work is to present an advance model of "Remote Controlled Hovercraft with Lift System and Spy Camera System". The control of this model is done by the help of Remote, which sends signal to the Micro-controller as an input signal. This input signal of micro-controller sends then supplies the necessary input to the hovercraft in the form of pulse signals in order to ensure correct power supply.

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Let us understand the basic parts of a hovercraft

Base plate

It is the basic foundation and most important part of the hovercraft on which the whole body is to be implemented. The base plate of hovercraft must have following:

- It must have a reasonable size for the total weight of the craft and payload
- Must be strong enough to allow the cushion (on landing surfaces)
- Must be watertight and as smooth as possible.

Hovercraft Skirts

It is a flexible material made of Nylon material. It is attached below the lower edges of the hovercraft base. As the hovercraft lifts, the skirt draws air underneath to keep much deeper air cushions. The skirt formation due the air enclosed in the skirt attached in bottom allows a hovercraft to keep its normal operating speed over every surface of water as well as going over rocks, ribs and gutters. The skirt material must be lightweight and flexible and at the same time durable.

Brushless DC Motor

Brushless motors are used due to its uniqueness of capable of producing more torque than any other dc motor and also it have a faster peak rotational speed compared to nitro- or gasoline-powered engines. Nitro engines peak at around 46,800 RPM and 2.95 HP, while a smaller brushless motor can reach 50,000 RPM and 5 HP.

The Lifting fan

These are the propeller which is used to lift the craft slightly above the ground surface by creating a cushion of air beneath the craft.

The Thrust Propeller

These are the propeller or fan which is/are used in order to provide the forward movement of the craft by creating a forward thrust.

Control System of Hovercraft

The control of hovercraft is done with the help of a remote which give commands to the micro-controller. Micro-controller receives the command from remote control and processes it and then sends it to the motors in the form of pulse signal in order to provide a desired operation.

V. TYPE OF DESIGN

In this section we introduces various types of hover craft models from the literature study made up of different body style and body material .

Design	Fan System	Body Shaped	Body Material	Skirt material
Type 1	Double fan System for propulsion, a single fan to produce lift.	Ellipse	Thermocol	Plastic bag
Type 2	Single fan system for propulsion, a double fan to produce lift.	Rectangle with rounded corners	Recycled plastic	Solid skirt made out of foam
Type 3	Combined lift and Propulsion System with a single fan.	Circle	Styrofoam	-
Type 4	Double fan system for propulsion, a single fan system for lift.	Circle	UFO [made out of balsa wood with a monocot skin	Poly-ethylene
Type 5	Single fan for propulsion, a single	Rectangle with	Recycled	Poly-

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	fan for lift	rounded corners	plastic	ethylene
Type 6	Double fan used for propulsion, a double fan used for lift system	Triangle	Foam	Plastic bag
Type 7	Combined thrust and lift fan system	Rectangular box	Recycled plastic	Foam
Type 8	Combined double fan and lift system	Shape of a car	Vacuum-formed plastic	Rubber
Type 9	Double fan for both lift and propulsion system	Rounded corner rectangle	Carbon fiber	Plastic

VI. DESIGN APPROACH

STEP 1 - Literature Analysis & Design Reviews

In this step, we conduct a research survey about the RC Hovercraft that on which principle they are working, various parts & technical aspects of the working model, what their practical implementations, their advantages, and limitations, more importantly, selection of materials for design purpose. In addition, technical aspects of manufacturing to make design safer, cost-effective, to find alternative materials to make design lighter in weight, make a design more aerodynamically and importantly more environmentally friendly. The literature survey is one the effective tool or approach for such observation to be carried out.

STEP 2: - Drafting Of Design of RC-Hovercraft

For the proper visualization of the model, we used 3D software like Pro/E wireframe4. Pro/ENGINEER is 3D CAD/CAM/CAE feature-based, associative solid modeling software. The constant modeling approach uses parameters, dimensions, features, and relationships to capture supposed product behavior and make an instruction that allows style automation and also the optimization of style and products development processes.

The Four main parts of a design are:

- Base Design [Means Platform]
- Lift Motor Mount Design [Lifting Mechanism]
- Thrust Motor Mount Design [Propulsion or Thrust Mechanism]
- Steering [Controlling Direction] Design

STEP .3 - Manufacturing Of RC-Hovercraft

• Manufacturing Objectives:

- 1) Build a working and autonomous RC hovercraft.
- 2) Make the lightest and most cost-efficient hovercraft possible.
- 3) Offer a new & improved design of the existing hovercraft (based on self-evaluation).
- 4) Make the environment-friendly Remote Controlled (RC) Hovercraft.

• Stepwise Manufacturing of RC-Hovercraft

- a) **Preparation of Base:** In this step, construction of a Platform & Skirt is done by Selecting Appropriate Size & Material for the base of hovercraft. Design, build a durable and lightweight body, skirt, and also finding the best placement of parts.
- b) **Preparation of Lift Motor Mount Design [Lifting Mechanism]:** In this step, the design for lift motor, which is to be mounted in the center of the base, is designed is done. For this purpose, we first choose an adequate place for a fan. Then powerful efficient are selected and fitted which propel the hovercraft.
- c) **Preparation of Back Motor Mount Design [Propulsion or Thrust]:** In this, the design for thrust motor, which is to be mounted on the back to provide the forward movement, is done.
- d) **Preparation of Steering (Controlling Direction) Design:** In this step, the steering action of the hovercraft is

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taken into account. The steering action is provided by the help of a remote control, which sends a signal to the receiver that processes it and sends it to brushless motors in the form of a pulse signal.

In the end, Assembly of all the utilities will be carried out with all the appropriate components.

STEP 4- Testing of RC-Hovercraft

After manufacturing testing parameters are tested. Some parameters tested are as follows:

- Working conditions monitoring
- Speed control
- Lift mechanism [means Cause to move upwards], and
- Turning [means a movement in a new direction].

VII. DESIGN SPECIFICATION AND COMPONENT USED

In this step we used Mechanical Cad software's 2D like Auto Cad for the objective of size specification.

- Base Design [Platform] of RC- Hovercraft.
- Thrust Motor Mount Design [Propulsion or Thrust].
- Lift Motor Mount Design [Lift Mechanism].

Component	Specification	No. of Units
Thermocol	Thickness: 18cm Width: 37 cm Length: 58cm	3
Brushless Motor	Weight: 80.6 grams KV Rating: 1000KV, 13T Thrust: 1200/4 gram/s Max Power(W) : 190/3 Max Current (A) : 17A	2
Propeller (Standard & Counter Rotating)	10 x 5 inch	2
Remote Control (Radio Control Transmitter & Receiver)	Channel 1 - For Steering Control Channel 2 - For Back Motor Control [Thrust or Propulsion] Channel 3- For Front Motor Control [Lift]	1
Relay Driving Circuit	11.1 V	1
Wireless Camera	-----	1

VIII. CALCULATIONS

Nomenclature

- a = Area
- l = length of platform
- b = Width of platform
- D_c = Co-efficient of discharge
- P = Pressure

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$$\begin{aligned}
 \rho_{\text{air}} &= \text{Density of air} \\
 \text{Exit} &= \text{Velocity exit} \\
 Q &= \text{Flow rate of air} \\
 \text{Weight of the RC-H} &= 2.5 \text{ kg.} \\
 \text{Length of the RC-H} &= 58\text{cm} \\
 \text{Width of the RC-H} &= 37\text{cm} \\
 \text{Total Area} &= (\text{Area of Rectangle}) + \\
 &\quad (\text{Area of Outer Semi-Circle}) - \\
 &\quad (\text{Area of Inner Circle}) \\
 &= (L \times B) + \left(\frac{\pi}{2} r^2\right) - (\pi r^2) \\
 &= (39 \times 37) + \left(\frac{\pi}{2} \times 18.5^2\right) - (\pi \times 12.5^2) \\
 &= 1443 + 537.605 - 490.874 \\
 &= 1489.176\text{cm}^2 = 14.89176 \text{ m}^2 \\
 \text{Pressure (p)} &= \frac{\text{Force(Weight)}}{\text{Area}} \\
 &= \frac{2.5}{14.89176} \text{ kg /m}^2 \\
 &= 0.16788 \text{ kg/ m}^2 \\
 \text{Area of the Air} &= \text{Length} \times \text{Height} \\
 \text{Cushion Vehicle gap} &= 58 \times 7 \\
 &= 406 \text{ cm}^2 = 4.06 \text{ m}^2 \\
 \text{Velocity Exit} &= D_c \sqrt{\left(\frac{2 \times p}{\rho_{\text{air}}}\right)} \\
 &= 0.53 \times \sqrt{\left(\frac{2 \times 0.16788}{1}\right)} \\
 &= 0.53 \times \sqrt{0.33576} \\
 &= 0.53 \times 0.57945 \\
 &= 0.30711 \text{ m/sec.} \\
 \text{Cushion Pressure} &= 1.3 \text{ p} \\
 &= 1.3 \times 0.16788 \\
 &= 0.218244\text{kg / m}^2 \\
 \text{Flow rate of air Q} &= \text{Velocity} \times \text{Area of air} \\
 &\quad \text{Exit cushion vehicle gap} \\
 &= 0.30711 \times 4.06 \\
 &= 1.2469 \text{ m}^3 / \text{sec.}
 \end{aligned}$$

IX. CONCLUSION

The development of air cushion vehicle controlled utilizing remote control was fruitful. In the wake of running a few tests to get the best program to work it, the hovercraft could go in any event most of the way around every course. This design utilizes a combined single trust and a lift system with a body shape of a rectangular box with round corner made out of thermocol and with a skirt made out of Nylon. We can use the alternative material or additional modification in design to extend the potency of craft. We can also improve the steering mechanism. Our design is safe and environmentally friendly because we are using a motor for lift and propulsion, which does not create any pollution while running. There is no chance of fire or explosion since fuel is not used, so a chance of an accident is reduced and our design become safer. We are using thermocol as a base material, which is light in weight, so the overall weight of our design is less. Our design is price effective because we are using thermocol and sun board ply for base and body, which are low price and easily obtainable material. Manufacturing of our design is very easy. There is no need for any machining operation. While testing we observe our design model will be capable to move in straight line. Our design is

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portable because of lightweight. The weight of our design is near about 2.5kg, so we can easily carry the RC-Hovercraft.

X. FUTURE SCOPE

Hovercraft is more affordable and smaller versions are available which make leisure ownership possible. In trying to predict the future trends, commentators have to consider changing circumstances; improvements in affordability of hovercraft. New technology like CAD and MATLAB provides new techniques to the engineering parts with tolerances for tighter than it is possible 50 years ago. As we know that, some peoples think that within coming few year hovercrafts will be no more visible to anyone. But with this new and latest technology used, we can say that there is no turning back for hovercraft and they will stay here with new modifications as well as new technologies. Today and in the future, a history of hovercraft will be written not only by inventors or by engineers. Therefore, we can conclude that the history of the hovercraft in future could be written by your neighbors building a newly modified hovercraft in their garage or by your child making it at school or by you.

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