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RESEARCH PAPER

THE MODELLING AND FABRICATION OF A PROTOTYPE REMOTE CONTROL MILITARY HYDROPLANE

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ABSTRACT

This paper describes the construction and the purpose of the use of the hydroplane for military applications. A Hydroplane is basically a vessel that is capable of moving on water but unlike vessels like ships and boats, hydroplanes have a different propulsion system. It uses propellers to drive air to generate enormous amounts of thrust to move forward, i.e. unlike ships and boats, the propellers for driving the vessel is fitted upwards. Normally, hydroplanes are used for sport and gaming purposes, but the hydroplane mentioned in this paper is for military application only. The entire vessel with all its systems weighs around 4 kilos including batteries. Till date the use of hydroplanes in the military has been limited to reconnaissance only by mounting cameras but the author has focused specifically on mounting weapons and a robotic gripper to serve specific needs required on an ongoing operation on a water body.

Keywords: Hydroplane, Propellers, Remote Control, Lipo Batteries, Brushless Dc Motors, Port Side, Starboard Side, Esc, Servo.

1. INTRODUCTION

A hydroplane is a mobile vessel which is able to move on water by the thrust generated by propellers mounted on top of the vessel. It creates enormous thrusts by the propellers to drive it forward. Hydroplanes are meant for sport and RC gaming events where speed is of the utmost importance but in this paper, the author has devised this hydroplane to be able to move stealthily on water with a comparatively low speed. The entire body of the vessel is made from wood and plastic. Plastic usage for construction has been chosen by the author to not only make the hydroplane lightweight but also to make it generate enough buoyant force to hold additional weight up to 1 kilo extra. The hydroplane itself weighs 4 kilos including batteries, electronic components, weapon systems, motors and the frame and still it can support an extra 1 kilo. Unlike an airboat, for better steering in water, the hydroplane has been equipped with a rudder which is fixed on the back of the hydroplane and is always immersed in water. When the hydroplane is in motion, this rudder inside the water, is moved left or right as per requirement to change the direction of motion. The weapon system and the mechanical arm are mounted on the hydroplane and are moved as per requirement by servo motors.

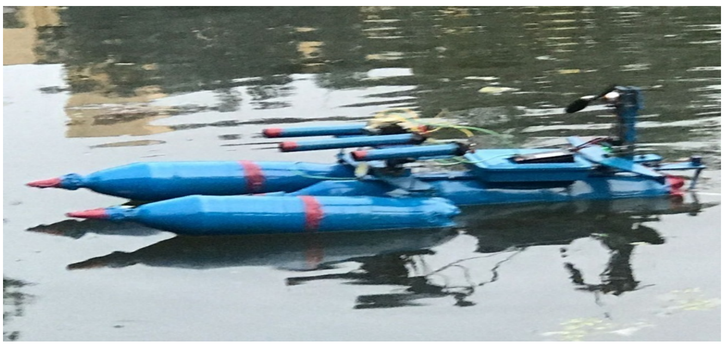

Fig. 1: The Hydroplane

A dowel fixed to the back of the hydroplane consists of the propulsion system, which is basically a brushless DC motor rotating at a high speed to drive a propeller to generate thrust. The entire frame of the hydroplane is made of 6mm plywood and on the frame are the entire systems supported. The electronic parts, the battery cabinet, the weapon system, the rudder controller servos, the propulsion systems are all fixed on this frame and underneath this frame, the plastic sheet which is enclosed like a cylindrical tank and filled with air, is fixed to the frame by means of nuts and bolts. For support 2 more plastic cylinders with air has been fixed and explained later in the paper. The entire system of propulsion and control of the systems on board had to be electronically controlled because the entire vessel has to be on water and the operations using this hydroplane might be conducted at a reasonable distance away from the user of the hydroplane hence, remote control systems had to be brought into use.

2. DESIGN

Using conventional machine tools, the author has built the prototype. Angle grinder, files and hacksaws has been used to cut the 6mm plywood into required shape and size. Holes for inserting bolts and screws had been done with a power drill.

A. Body

The frame of the hydroplane has been made from 6mm plywood and the frame is basically a T-shape frame. Two pieces of plywood of length 400mm by 50mm and 600mm by 50mm has been used to make the T-shaped frame. The plywood piece of 600mm by 50mm has been placed as the vertical part of the T-frame where the plywood piece of 400mm by 50mm has been fixed as the horizontal part of the T-frame. Beneath the longer length plywood piece is the rolled plastic cylindrical tank of dia 80mm is fixed. The plastic cylinder is of length 750mm and the front facing part of the cylinder has been turned into a protruding conical shape. This conical shape is done on the plastic cylinder head to reduce the drag created by the water surface when the hydroplane is in motion. This plastic cylinder is fixed with the plywood piece of 600mm by 50mm by means of two bolts. The two arms of the T-frame, i.e. the horizontal plywood piece of length 400mm by 50mm contains two more plastic cylinders of shorter length of 500mm with the same diameter. The two cylindrical tanks are fixed to the two sides of the T-frame to support and balance the distributed weight on the hydroplane along with for providing extra buoyant force to the front of the hydroplane. The dowel consisting of the propulsion system is fixed to the extreme back of the frame along with the rudder controller servo motor and in front of them, the cabinet consisting of the electronic, control and power systems are fixed. The weapon/mechanical arm system is mounted on the front of the hydroplane.

B. Propulsion System

The propulsion system of the hydroplane is a unique one. Basically if the driving propeller is underwater then there are chances of underwater damage with various objects and plant-life disturbing and damaging the propeller while the propeller is revolving**.** So, if the propeller is in air, neither are such disturbances present to damage the propeller but also, the electronics and the electrical wirings of the system are prevented from damage due to water.

Fig. 2: The 2200 kv brushless motor and propeller

The propeller, with every rotation draws and pushes air backwards to generate a considerable amount of thrust to make the hydroplane run at speeds of more than 20kmph with all the weight on board. The entire setup is fixed on the frame, where a wooden dowel of thickness 20mm, length 200mm and breadth 20mm is fixed to the back of the T-shaped frame. This wooden dowel has two 6mm plywood pieces of length 40mm by 40mm fixed on two sides of the dowel by means of screws and these two plates are fixed from the upper side with a long screw. On the first wooden piece fixed on the dowel facing to the front, a brushless DC motor of 2200kva is fixed by means of screws and nuts. This motor rotates at a speed of 26400rpm, and to the shaft of this motor is a double blade propeller fixed. Rotating at such a high speed, over 4 kilos of thrust is easily produced to drive the hydroplane forward. The propellers used are 10 inch double-blade props.

C. Steering System

A 9gm servo motor is fixed at the extreme end of the T-frame just behind the wooden dowel. This servo motor can rotate only up to 90 degrees both left and right from the centre. The servo motor shaft contains a thin wooden shaft of length 100mm fixed with an aluminium plate. This plate is of length 100mm by 50mm and is of enough surface area for an easy steering of the hydroplane. This entire setup of the wooden shaft fixed with the aluminium plate can be rotated both sides up to 90 degrees thus displacing and pushing enough water aside for easy steering.

This entire setup is known as the rudder, and as the rudder rotated to the left, the hydroplane moves towards the right direction or **Starboard side** and as the rudder rotates to the right, the hydroplane moves to the **Port side.** The turning circle of the hydroplane is approximately 6 meters.

Fig. 3: The Rudder

D. Weapon system

Situations might arise in an operation conducted using the hydroplane where the need for engaging multiple targets and making a hasty retreat is gravely essential. With the self weight of the hydroplane itself along with everything onboard the hydroplane, carrying huge and heavy weapon systems on board is not possible for the hydroplane. Specially in engaging hostile human-sized targets, assault rifles and machine guns are needed to be fixed to make a difference in the contact scenario, but due to the limited weight capacity to be on board on the hydroplane, the author has incorporated an unconventional weapon system that will able to buy time for a hasty retreat from a highly dangerous contact scenario as well as make some damage to the hostile targets.

Fig. 4: The weapon system

The weapon system mounted consists of a controller system using 2 servo motors. Unlike the servo motor used for the rudder steering, these servo motors are able to rotate at a full 180 degrees at both left and right side.

A rectangular plywood frame has been used to mount 3 rocket tubes for firing rockets. This entire platform is able to rotate upwards at an angle of maximum 45 degrees with the help of a servo motor. Though the servo motor can rotate the entire platform at much higher angles but with steel wire constraints, the rotation of the platform has been limited between angles of 0-45 degrees only.

The firing of the weapon system is also dependent on the operation of a single servo motor. Here a switch is taken with one terminal directly connected to the negative terminal of a 12 volt 1.3AH battery while the other terminal of the switch is connected with 3 wires, which are soldered together. Here, the 3 wires are connected respectively to 3 negative ends of 3 copper coils which are fixed inside each respective rocket tube. The other end of the copper coils are connected and soldered with the help of 3 more wires, which are on the other hand connected with the positive terminal of the 12 volt battery. Hence, the switch here basically opens and closes the circuit that controls the operation of heating the copper coils in each respective rocket tube. The switch in the circuit ignites all the coils at the same time. One servo operates the switch that switches on and switches off the circuit.

This entire switch operation and coil ignition can be described as the trigger mechanism.

Fig. 5: The servo motor operating the switch

The rocket tubes each contain one rocket respectively. Each rocket tube is filled up to a centimeter in matchstick powder, covering the copper coils inside each tube. This matchstick powder is then ignited by the heating of the copper coils, acting as the primer for the rocket ignition. The rockets inserted in each rocket tube basically are ignited by this burning matchstick powder and shoots off from the rocket tubes.

The rockets fired are basically explosive shells of diameter 15mm and length 80mm. These rockets are propelled by the fuel composed of highly pulverized matchstick powder only. This pulverized matchstick powder fuel has enough energy to propel the rocket to 20 meters. The rocket body at the end has 3 nozzles fixed to generate a much more balanced thrust to keep the nose of the rocket steady during flight. At the tip of the rocket there is a firework explosive which detonates as the rocket fuel comes to an end of burning and mostly the fuel completes burning within 2 seconds of ignition. The entire body of the rocket is made from tin.

This kind of weapon system is ensured to not only fire and hit a target from the hydroplane but also to cause considerable damage to the intended target with an explosion.

E. Mechanical Arm

The mechanical Arm has been fixed here for optional purposes. While the mechanical arm is fixed on the hydroplane, the hydroplane is not able to contain the weapon system on board at the same time. Hence, the mechanical arm is fitted on the hydroplane only during operations involving no hostility or involving no combat situations.

There might be situations in a operation where the hydroplane might have to be used to grab any required object from the water. Here, the mechanical Arm is to be used.

Fig. 6: The Mechanical Arm

The mechanical arm is 300mm long and is made from entirely plywood. A 200mm long and 20mm thick, being 8mm thick, this plywood piece is used on which one side has a 9gm servo motor fixed. This is the same servo motor as the one which is used to rotate the rudder. Likewise, this servo motor can rotate only 90 degrees to the left and 90 degrees to the right. With this servo motor the palm of the mechanical arm is fixed on which the jaws for the gripper are fixed. On this palm, another similar servo motor is fixed with which a single arm of the gripper is fixed. With command to the servo, this gripper arm can move right or left and to the left side, it touches with the fixed arm of the gripper. Thus, one side of the gripper is arm is fixed while one side is movable.

The weapon system has a servo motor that rotates the rocket tube platform from 0-45 degrees. Removing the rocket tube platform from the servo motor's shaft, the arm is fixed. The wire constraints are removed so that the arm can rotate 0 to 90 degrees and -90 degrees as well.

3. ELECTRONIC CONTROL SYSTEM

In this project the electrical components that have been used are as follows:

A) 2200 kv brushless dc motor

Brushless dc motor is a motor which is powered by dc current but from a switch mode power supply with a variable frequency. So the dc current is not given directly via an esc which is nothing but a device which will convert steady dc to a pulsating ac which is used to drive the motor.

Brushless dc as the name suggests, the rotor is the magnet with the axel where the coil is steady. The current is passed to two pairs of coil which are in diagonal to each other which makes a torque in a direction. Next again, 2 pairs of coil opposite to the previous coil to provide another set of torque and vice versa. Hence, and ac pulsating signal is sent to the pairs of coils so that they turn off and on at a frequency produced by the ESC.

B) ESC or Electronic Speed Control

ESC is a set of 3 pairs of mosfets which is clocked by a 555 timer IC so as to provide the desired output i.e. the frequency and can be alternated by changing the clock of the IC.

Here, a 60 Watts ESC is used. This ESC is used to control the 2200Kv brushless DC motor mainly along with the 3 servo motors. The 2200kv brushless DC motor consumes such a amount of current that the ESC gets damaged due to the huge amount of heat generated for the current passing through it. Hence, this 60 Watts ESC used consists of a heat sink fixed to the ESC module along with a cooling fan to drain the extreme heat generated in the ESC while the 2200kv brushless DC motor is made to run at its full speed.

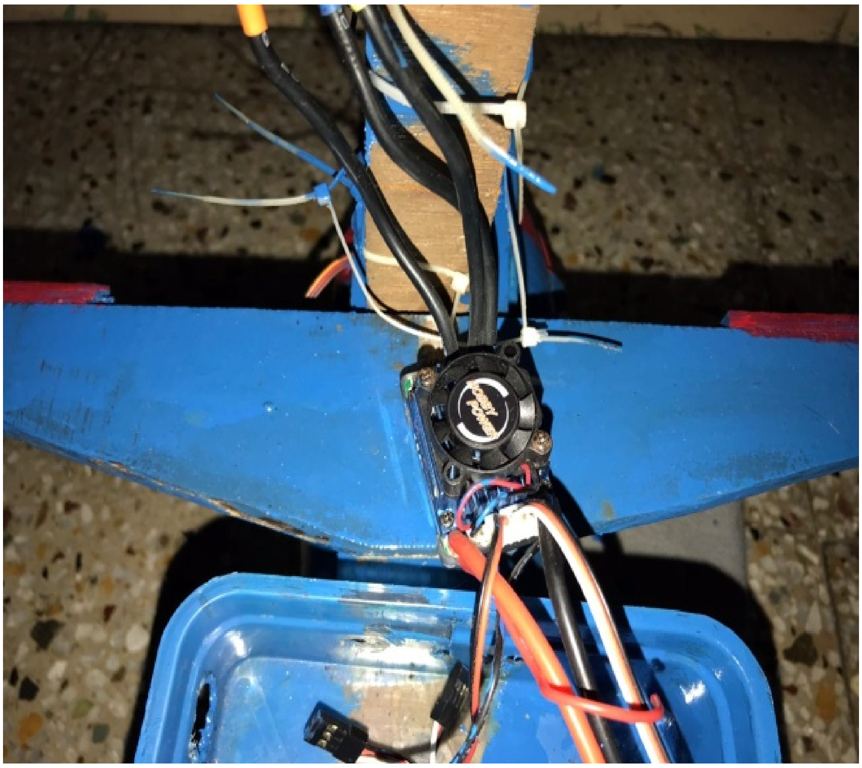

Fig. 7: The 60A Electronic Speed Controller

C) Servo Motors

Servos are basically motors which can make an angle and stay there instead of spinning.

Servos come with an IC which can provide an alternating frequency which lets the motor vibrate at a certain desired angle. Receiving command from the transmitter to the receiver, the servo motor receives command to move as per the desired angle directed by the transmitter. Some servos can only make a rotation up to 90 degrees both to the left and to the right while some servos can have at maximum rotations up to 180 degrees to both left and right side..

D) Lithium Polymer Battery

The Lithium Polymer Battery used here is a 2200mah lipo, which delivers a constant power at 11.1 volts steadily with no fluctuation. Being lightweight of just 175 gms, this lipo battery can deliver a maximum continuous discharge of 66 Amperes of current and a maximum burst discharge of 132 Amps. In the hydroplane, the only highest power consuming unit is the 2200Kv brushless DC motor, so here, the lipo battery comes into play to deliver such a huge amount of power yet being so light weight at the same time. The servo motors installed consumes very less amount of power and yet the servo motors can operate at a fluctuating power supply that normal 12 volt batteries generate, but a brushless DC motor requires a stable and steady power supply, so without lipo batteries it is impossible to drive the hydroplane.

The lipo battery used here is a collection of 3 cells that generates 3.7 volts each, and hence the 3 cells generate 11.1 volts altogether. All the cells are rechargeable ones of lithium-ion technology using a polymer electrolyte. High conductivity gel polymers form this electrolyte Lipos work on the principle of intercalation and de-intercalation of lithium ions from the positive electrode and the negative electrode with the liquid electrolyte medium.

E) Transmitter and Receiver

The hydroplane and its functions are controlled by a remote. Along with the remote, a channel is available, and here, the remote is the transmitter and the channel is the receiver. It is a 6-channel receiver allowing at max 6 sets of control wires to control at max 6 motors. Here, only 3 servo motors and 1 brushless DC motor is connected via the ESC to the channel. So, using the remote, all the motors are controlled by a pair of control levers and the respective connection of the control wires with the channels decide the movement of the motors as per the movement of the control levers.

Fig. 7: The Lithium Polymer Battery

4. CONCLUSION

This military category hydroplane can be used for various operations on a specific water body, ranging from reconnaissance to a retaliatory objective. It is made from easily available materials and thus is cost-effective to be produced in mass numbers. With the availability of lightweight weapons, the hydroplane can be easily mounted with such weapons with a slightly powerful set of servo motors and some modifications, but as per Indian Gun laws, the author has not used such lightweight military grade weapon systems. The entire body can be easily made of air-filled steel tanks with armor plating instead of the plastic material used by the author, and much powerful brushless DC motors with much greater torque and higher speeds can be fixed to achieve speeds up to 50 kmph. Also, with the same 9gm servo motor fixed to move the rudder, the system can be changed to turn it into an airboat from a hydroplane, by fixing the rudder system upwards and driving air on the rudder plate. The entire hydroplane is flexible to afford any changes to the system and thus can be used in any military scenario.

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