Design and Modeling of RC Submarine

Mya Hnin Su, Aung Bhone Pyi

***Abstract*—Nowadays, RC (radio control) submarine can be used to do underwater monitoring. In this project, the cost will be optimum and using an easy to obtain parts. The main things in the RC submarine are controller system and watertight. The important components in the controller circuit are ESC and radio control module and propeller motor. For direction control servo motor is used to control surface unit. The ballast tank is made from PVC (poly vinyl chloride) pipes, sockets and round shape. To make a control system for the ballast system is the tough challenge in this project. The circuit is sensitive and easy to malfunctions. The submarine can be controlled by using remote control device and can broadcast underwater scene using on board wireless camera.**

***Index Terms*— submarine; ballast system; remote control; wireless camera.**

1) INTRODUCTION

To monitor the underwater, RC submarine are used. The submarine design and specification depends on the usage of the submarine. For deep water monitoring, the submarine can stand pressure and the control system can handle the long range under the water. RC submarine have been widely used in ocean exploration, military and industrial applications. The wide range of applications have resulted in development of hundreds of Subs with a variety of shapes, sizes, working depth limits, sources of energy, means of propulsion and ways of control.[1]

2) LITRATURE REVIEW

3) Ballast System

In order to travel underwater, submarines must work with some Fluid laws of nature, including Archimedes' Principle and Boyles' Law. Submarines are completely enclosed vessels with cylindrical shapes, narrowed ends. The others physical parts for a submarine are sail, rudder propeller, sterns and radio antenna. The ballast tanks control the sub's buoyancy.

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4) Ballast Tank

A submarine may have several types of ballast tank, the main ballast tanks, which are the main tanks used for diving and surfacing, and trimming tanks, which are used to adjust the submarine's attitude both on the surface and when underwater. A ballast tank is a compartment that holds water. A vessel may have a single ballast tank near its center or multiple ballast tanks typically on either side. Adding ballast to a vessel lowers its center of gravity, and increases the draft of the vessel. [2]

5) Buoyancy

The force exerted upwards by the water is called *buoyancy force*. This force is equal to the weight of the fluid displaced:

$$Buoyancy\ Force = weight\ of\ the\ fluid\ displaced.$$

Neutral buoyancy is obtained when the buoyancy force is equal to the gravitational weight of the object. [2]

To achieve neutral buoyancy in water, the mass of the object in kilograms must equal the volume of the object in liters. This result only applies for water. That is:

$$Mass\ (kg) = Volume\ displaced\ (Litres)$$

6) Mechanism

Because of the irregular shape, it is important to placement of the internal components such as controller, propellers and battery compartment in their respective positions without any overlapping.

The internal parts are placed in a middle body is generated automatically covering the internal arrangement, and then nose, rear propeller and tail cone are attached along with the mid-body.

The constraints on lever arms and CG/CB separation is the optimization problem for the identification of a vehicle hull form with minimum drag and optimal placement of the internal objects. The higher value of lever arm produces higher pitching and turning moments that lead to better diving and heading changes. The CG/CB separation (*s*) is the longitudinal distance of the centre of gravity from centre of buoyancy. The lower the value of ***s***, the closer the position of the CG and CB that leads to better stability of the vehicle. Minimization of drag is important because minimum drag leads to least power consumption for propulsion, and corresponding savings in the operating costs. [3]

As a drag Estimation, the optimized hull design vehicle is a minimum drag to reduce the submerged vehicle power requirements. For drag estimation, the following formula has been used:

$$D = \frac{1}{2}\rho V^2 C_V A$$

where ρ is the density of the fluid in kg/m^3, V is the velocity in m/s, A is the wetted surface area of the vehicle in m^2, and C_V is the coefficient of viscous resistance for the smooth bare hull.

7) PROBLEM STATEMENT

One of the problems is to get the optimum hull form is to minimize drag. Small improvement in drag can result in a substantial saving in thrust requirement. The optimizing the hull form design is needed to minimize drag and increase propulsion efficiency.

The next Problem is to find the optimum hull form for the optimum placement of the internal components and factors affecting controllability, i.e. the centre of gravity (CG) and centre of buoyancy (CB) effects. The design of a submarine in this project represents a torpedo-shaped underwater vehicle by simultaneously considering both internal arrangement of on-board components and external size. The objective is to find an appropriate hull shape to minimize drag and optimum placement of the internal objects for optimal CG/CB separation thereby ensuring better controllability of a vehicle moving submerged.

The current RC submarines are really expensive. This project embarks on submarine project where the submarine will be controlled using remote control device. There are some obstacles in controlling range of between receiver and transmitter.

8) DESIGN AND CONFIGURATION

The design concept of the submarine is based on the development of a small, light-weight vehicle that can be easily launched, recovered and operated. The design requirements chosen in this study are:

- Speed is 0.5 m/s
- The vehicle to be propelled by one rear propeller and two control Surfaces (panel) for vertical and lateral movements
- Cost effective

9) *Hull design and Mechanism*

The hull size of the toy submarine is constrained by the space for the onboard instruments that needs to be carried, and the hull shape is constrained by the hydrodynamic characteristics for minimization of drag.

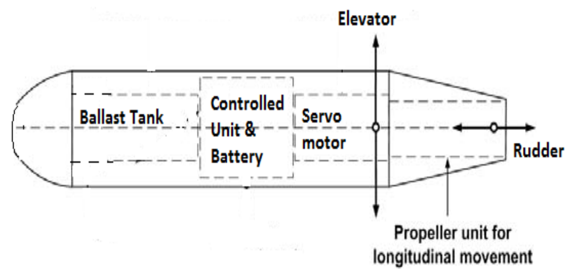

Figure 1.Configuration of the propulsion system

The materials for the design vehicle should have the following properties:

- good resistance to corrosion
- high strength with lightweight
- cost effective

The Polyvinyl chloride (PVC) water pipe for its intrinsic properties fits best for all the above requirements, and PVC production negatively affects the natural environment and human health, therefore, has been chosen for this study. [6]

10) MATERIALS AND CIRCUIT DESIGN

11) *Battery*

The battery provides power to all electrical components. The receiver picks up radio waves from the transmitter (controller). The receiver can then send signals to servos, and relay switch which can turn on the pumps and valves. The battery can be recharged by disconnecting the wires between the battery and power harness. Because this wire is outside the water-tight container, it means the battery can be recharged without having to open the container.

The battery stores an electrical charge. When the circuit is completed, negatively charged electrons travel from the negative terminal of the battery to the positive terminal. These moving charges release energy. The amount of energy can be calculated from two quantities, voltage and current:

$Power\ (Watts) = Current(Amps) \times Voltage(Volts)$

These two quantities are best explained with a water analogy. An electrical current is a flow of charged particles. In a river, current is a flow of water particles. Because of these similarities, electrical circuits can be related to a flowing river. A battery is like a hill. Water travels from the high ground to the low ground. In a similar way electrons travel from areas of high negative charge to low negative charge. Current can be thought of as the amount of water going down the hill. In electrical circuits the current is simply the number of electrons that pass a certain point in the circuit.

Voltage can be viewed as the difference between the high ground and the low ground. If the hill was steep then we would expect the water particles to be pushed by gravity more and hence travel faster down the hill. In electrical circuits the voltage is the electrical potential difference between the positive and negative terminals of the battery. [4]

The circuit diagram of model submarine is shown in figure.

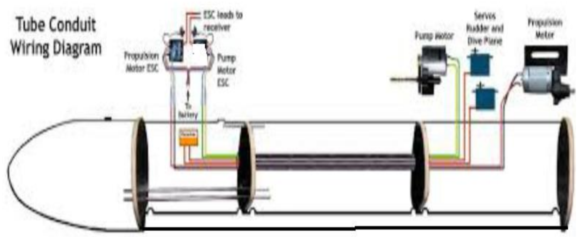

Figure 2.Circuit diagram of Model submarine

12) Power Harness and Motor

The power harness connects all the required electronic parts to the battery. A brushless motor integrated directly with propeller is used for drive the vehicle.

13) Receiver and Transmitter

The transmitters and receivers which use some form of energy (e.g., radio frequency (RF) to transfer information without the use of wires. Information is transferred in this manner over both short and long distances.

The Transmitter is the controller. The controller sends radio waves through the air and water to the receiver. The receiver picks up these waves and can decode these signals. Each button and direction on the joystick corresponds to a channel. Each channel on the receiver is normally the backwards and forwards motions on the right joystick.

Each channel on the receiver has three pins. Three wires (normally red, black, and white) are connected to these three pins. The black and red wires provide power to the part connected to the receiver and the white wire sends the control signal.

The only exception is the channel that goes to the electronic speed controller (ESC). In that special case the black and red wires power the receiver instead of the receiver powering it. Some ESCs do not have a battery elimination circuit (BEC), which means the receiver needs to be powered by other means.

14) Pump

Pumps work by using mechanical forces to push the material, either by physically lifting, or by the force of compression. Just like valves, pumps have an inlet and outlet. When the pump is powered on air or water is sucked in from the inlet and blown out the outlet.

15) Electronic Speed Controller (ESC)

Unlike valves which are either on or off, the motor can rotate at many different speeds. The speed controller decodes the signal from the receiver and adjusts the power to the motor according to the signal. This allows the motor to spin at a wide variety of speeds. The speed controller also powers the receiver, unless it has no BEC.

16) Servo motor

A Servo is similar to a motor however it knows how many degrees it has rotated to a much higher precision level. This makes it ideal to move the control surfaces of the submarine. It also can be powered directly from the receiver and does not need a speed controller or a relay.

17) THE OPERATION OF THE SYSTEM

The control surfaces are used to maneuver the submarine in the water. Each control surface is connected to a metal rod, which is attached to a servo. A servo has an arm that moves in a circle. When the servo moves, the corresponding control surfaces move accordingly. These control surfaces are similar to that of flaps on an airplane’s wings. The motor pushes the submarine forwards and backwards in the water depending on its direction of rotation. The ballast tank controls the buoyancy of the submarine to allow it to move up and down.

To achieve the required design speed of 0.5 m/s, optimization of the entire vehicle needs to be done to reduce drag to a minimum while increasing thrust to a maximum to improve the efficiency of the propellers.

For this project, ballast tanks are used to allow the vessel to submerge, water being taken in to alter the vessels buoyancy and allow the submarine to dive. When the submarine rise to the surface, water is blown out from the tanks using compressed.

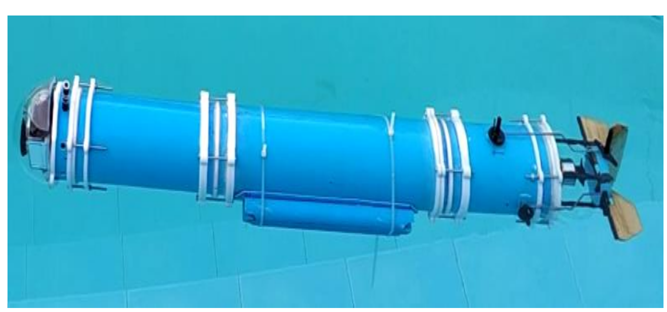

Figure 3.Configuration of the model submarine

The water pump is placed inside of the ballast system. The pump is used to transfer the water into the ballast tank when the submarine wants to dive and to transfer the water out the ballast tank for the submarine to rise.

By using pumps, water can be blown out from the ballast tank, causing them to be light. This creates positive air pressure in the ballast and therefore the buoyancy increases. When the buoyancy of the submarine exceeds neutral buoyancy the submarine rises in the water.

When the buoyancy of the submarine exceeds neutral buoyancy the submarine rises in the water. When the submarine is ready to descend into the water, pump system of the submarine absorbs the water back into the water tight container. This causes the submarine to contract, hence the buoyancy decreases. When the buoyancy is below the neutral buoyancy the submarine descends.

Figure 4.Control surface of model submarine

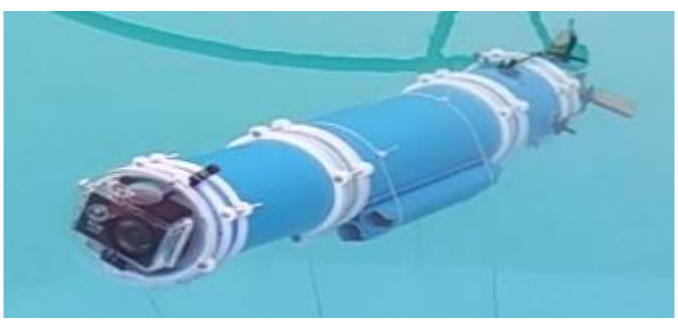

Figure 5.Front view of model submarine

18) RESULTS OF EXPERIMENT

Configuration of the internal component of the toy submarine is shown in Figure 2. This model submarine has propellers and control surface to allow it to ascend, descend, turn and move forward and backward. It is emphasized that the driven structure of the framework allows for design of underwater vehicles of various sizes, propulsions and power systems. The specifications and performance data measured for this model submarine are also listed in Table.

Measured Data (Table)

Vehicle Particulars	Resultant
Nose length	67 mm
Parallel middle body length	231 mm
Tail length	125 mm
Length overall	423mm
Maximum diameter	64.25 mm
Length to diameter ratio	6.7
Front surface area	0.0637 m^2
Total mass of the vehicle	446 g
Nominal speed	0.5 m/s
Working depth	3.8m

19) CONCLUSION

The main objective of developing a model design of a small-scale, low-cost, lightweight submarine for recreational purposes has been partially fulfilled.

The project of submarine can be controlled using remote control device and can broadcast underwater scene using on board wireless camera. This will be local made submarine. With this, the cost will try to mi minimize and using an easy to obtain parts.

The design of submarine is derived only renewable energy such as water or air. In significant sense are only propeller unit needs to drive. So a little amount of energy is needed to drive this vehicle. Therefore, it is an effective design for next generation.

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