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DESIGN AND CONTROL OF UNMANNED UNDERWATER VEHICLE FOR INSPECTION OF UNDERWATER INFRASTRUCTURE

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ABSTRACT

Underwater search robots have been a popular choice for observing the depths of ponds, lakes and oceans alike. The objective of the paper is to design and fabricate such a robot, which will survey and inspect shallow lakes. The Remote Operated Vehicle (ROV) described in the following paper consists of modules which look into the acquisition of data such as videos, images. The device will also determine and identify any undesirable objects lying at the bottom of the lake, to be removed to maintain the ecology of the lake, or respective water body. We propose a low-cost approach with a minimal and simplified configuration of thrusters and communication through wired media.

Keywords: Underwater Drone, UUV, Underwater Inspection.

I. INTRODUCTION

Remote Operated Vehicle (ROV) falls under the category of Unmanned Underwater Vehicle (UUV) that are used for underwater exploration for carrying out several challenging tasks underwater [1]. ROVs are tools used to inspect, survey and observe underwater objects using cameras in real time. The ROVs are operated using a tether cable linked to human interface devices such as joysticks, keyboards, touch panels, etc. They can also be autonomous and connected to the mother ship. Such ROVs are called Autonomous Underwater Vehicles (AUVs). However, driving ROVs can be a tedious task since they can be subjected to external disturbances and thus need skillful drivers for the fulfillment of any given task.

The proposed design of ROV has the application of exploration of lake beds while keeping in mind the cost effectiveness, portability and ease of control of the vehicle. The priority here was the real-time data telemetry between vehicle and operator. For a successful expedition, the presence of a human operator helps in a mission plan as humans can react to sudden changes caused by the unpredictable nature of the lake environment. Modern ROV systems are categorized by size, depth required, onboard horsepower, capability, and whether they are electrohydraulic or all electric.

The proposed design of the submersible ROV is a small class ROV that are micro and mini ROVs with power less than 5hp. This paper describes the design and fabrication of a submersible ROV used for the visual inspection of lakes. It was designed taking into consideration the pressure and the temperature underwater in different parts of the lake. The ROV was designed emphasizing on the reduction of cost, ease of control and portability of the vehicle.

II. RELATED WORK

In the later years of the 20th century, the research on manned underwater vehicles boomed to accentuate the understanding of various chemical, biological, geophysical and geological processes transpiring in the depths of lakes, oceans, ponds and seas. The study of phenomena undersea began in the 1970s with Project FAMOUS [2] along the Mid Ocean Ridge [3].

The demands for ROVs began to increase during 1980s and were mostly required by the oil and gas industry [4]. Since then, extensive research has been carried out and the development of UUV nowadays is being done for deployment in several areas of interests. Currently, UUV are used in research in the maritime sector to inspect the ship's hull condition [5]. They are also used in oceanographic discovery and water pollution research [6].

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A category of UUV known as Autonomous Underwater Vehicle [AUV] have also been seen which are controlled automatically by on-board microcomputers and can work independently. Whereas ROVs are remotely controlled by the human operator with the help of a cable or wireless communication [7].

ROVs have been in the picture for the detection of underwater archaeological objects and SURF algorithm was developed for the same [8]. Deep water ROVs have been put into motion and also modified to take samples from the sea bed for further research. For the oil industry, ROVs have been proved to be a boon as the deep waters have high water pressure and it is impossible for divers to dive in, [9].

They have been used for the construction of offshore gas and oil fields, as well as for their maintenance. The Mexican Oil [9] and the power industry ROV are a couple of examples of such vehicles.

Apart from the main industry specific ROVS, the research based vehicles to enhance knowledge such as "DENA" .

III. DESIGN CONSIDERATION

a. Design of a submersible ROV

The design of a submersible ROV necessitates a detailed consideration of design parameters and operational characteristics. The generic design process consists of the following stages: (i) Definition of problem statement, (ii) Identification of parameters, (iii) Selection of material, (iv) Determination of forces (v) Design. The operational factors aimed for are: low cost, ease of control, portability and effective survey capabilities .

b. Definition of problem statement

The problem statement to be dealt with was the surveying of lakes for scientific as well as ecological purposes. It comprised the measurements of temperatures and pressures in various regions underwater and the visual inspection of lake beds along with detection and identification of foreign objects.

c. Selection of material

Keeping in mind the low-cost requirements and the operating environmental conditions, PVC pipe was used for the construction of the hull. The properties of PVC pipe are known to be its considerable weight reduction, good chemical and physical properties such as corrosion resistance, stiffness, shock absorption and neutral chemical behavior.

d. Determination of forces

The underwater forces acting on an object depend on various factors such as the object's shape, size, density, and the fluid dynamics of the surrounding water. However, some common forces include:

1. Buoyancy: This is the upward force exerted by a fluid (in this case, water) on an object submerged in it. It is equal to the weight of the water displaced by the object. Archimedes' principle states that the buoyant force is equal to the weight of the fluid displaced by the submerged part of the object. This force opposes the weight of the object, and if the buoyant force is greater than the weight of the object, the object will float.
2. Drag Force: When an object moves through water, it experiences resistance from the water, known as drag. This force depends on the object's speed, shape, and surface area. Drag force acts in the opposite direction to the object's motion.
3. Hydrostatic Pressure: This is the pressure exerted by the weight of the water above the submerged object. It increases with depth and acts equally in all directions. It contributes to the overall forces experienced by the object but might not have a specific direction like buoyancy and drag.
4. Added Mass: When an object moves through water, it pushes water out of its way, resulting in a mass of water being "added" to the system. This added mass affects the object's inertia and dynamic response to changes in motion.

These forces can be complex and are often analyzed through fluid dynamics simulations, experiments, or theoretical calculations depending on the specific scenario and requirements. Additionally, the behavior of underwater forces can vary significantly based on the object's velocity, depth, and the properties of the water itself.

e. Overall Block Diagram

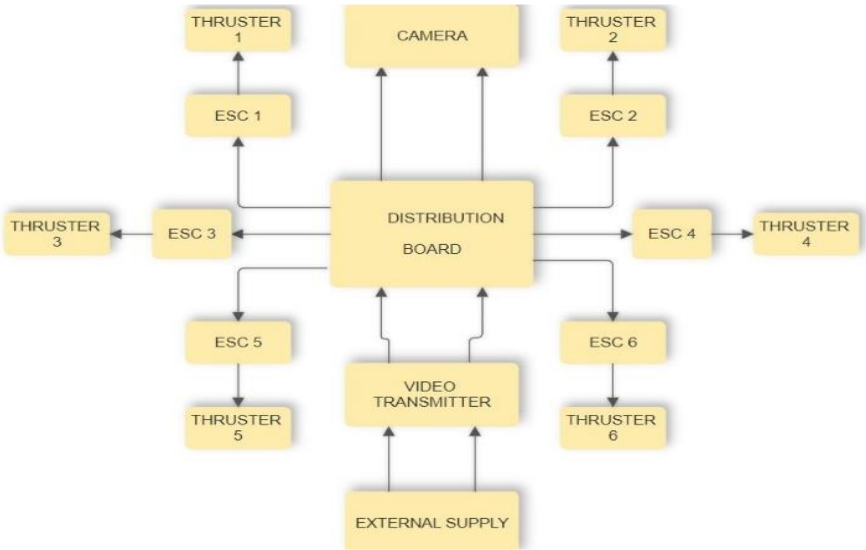

Figure 1: Block Diagram

IV. ELECTRONIC COMPONENTS

a. BLDC Motors

BLDC Motors are used to rotate the propellers connected to it so that it can provide the required thrust to move the ROV with proper control.

These types of motors are very efficient and can also be cost effective.

b. ESC (Electronic Speed controller)

ESC's are used to control the speed of BLDC motors by using PWM method. This provides very efficient controlling of BLDC motors and eventually the thrust of the motor.

c. FPV Camera

A small FPV camera was used to take the live footage of underwater objects and to inspect the surroundings.

The output of this camera is taken out by its transmitter and we see a live footage in mobile or FPV goggles.

d. Power Supply

A 12 volt dc power supply was used to power all the thrusters. A LiPo battery was used of 8000 mAh capacity.

V. RESULT

Loose basement Threads of the pipe mount:-

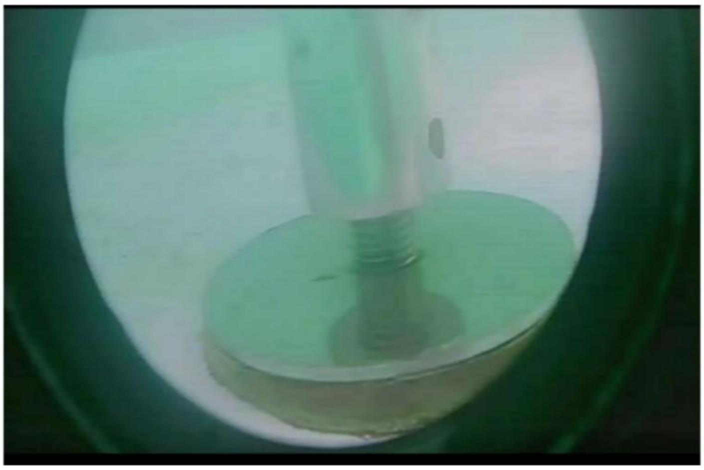

Figure 2: 1st Observation

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Pipe welding Live video Footage:-

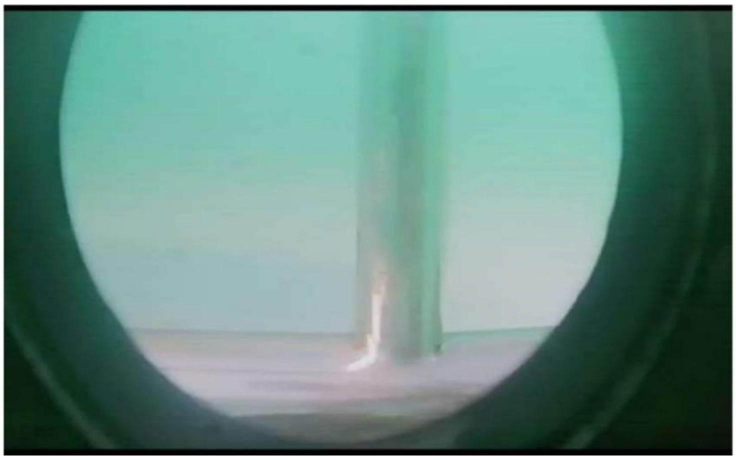

Figure 3: 2nd Observation

VI. CONCLUSION

After conducting the trial of our Unmanned Underwater Vehicle (UUV), we are pleased to report that the outcomes surpassed our expectations. The camera outputs provided clear and visible evidence that the design and configuration of the UUV enabled smooth and precise movement. This is a significant achievement, as it validates our efforts in refining the technology for underwater exploration and surveillance.

VII. REFERENCES

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