Automated Hull Cleaning and Monitoring Robot

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Abstract - *Towards the end of the 20th century, a chemical called Tributyltin was introduced into many hull paints with an illusory promise that ship hull cleaning would no longer be necessary. Like in many other areas in life, substituting hard work and manpower for chemicals was not the answer. Not only did this chemical not work in keeping hulls permanently clean, but it has also been found to be extremely toxic to our oceans, causing extensive marine damage. This is why we need to make use of a subsea hull cleaning service regularly. Regardless of the bottom paint, at the very least a layer of biofilm will develop. These are microorganisms, usually bacteria, which clump together and then attach themselves as a group to a nearby surface. This biofilm then develops a slimy surface in order to protect itself. In severe cases, ship hulls can also collect seaweed and barnacles. Therefore, the underwater surfaces of vessels need to be kept clean to keep them operating efficiently. This will not only save money on fuel but will also reduce the carbon footprint, allowing us to play your part in the fight against climate change.*

Key Words**: underwater cleaning robot, bio-foul cleaning, live monitoring**

1. INTRODUCTION

Towards the end of the 20th century, a chemical called Tributyltin was introduced into many hull paints with an illusory promise that ship hull cleaning would no longer be necessary [5]. Underwater robots are being developed for a variety of purposes, including inspection, maintenance, and cleaning of underwater structures and surfaces [8]. Not only did this chemical not work in keeping hulls permanently clean, but it has also been found to be extremely toxic to our oceans, causing extensive marine damage. This is why we need to make use of a subsea hull cleaning service regularly. Regardless of the bottom paint, at the very least a layer of biofilm will develop. These are microorganisms, usually bacteria, which clump together and then attach themselves as a group to a nearby surface. This biofilm then develops a slimy surface in order to protect itself. In severe cases, ship hulls can also collect seaweed and barnacles. Hulls of large ships in service need to be periodically cleaned for safety inspections and reduction of drag force. A ship that operates with a clean underwater surface can potentially save over 5% of fuel cost [5].

Even when the antifouling substances are used, ships need to undergo cleaning operations at regular intervals, both for removing fouling that was not avoided by the paint and to remove the paint itself (which has around a 5 year effective lifespan) through blasting operations that produce large amounts of toxic waste in addition to the very high cost of the process [2].

Recently underwater robots are applied to various missions such as observations of underwater structures oil-well drilling rig on deep ocean, bridge piers, discovery of unknown creatures, ecology investigations, maintenance of underwater cables, investigation of hydro-thermal vents and underwater volcanoes [3].

Autonomous Underwater Vehicles are playing an increasingly important role in exploration and exploitation of underwater environment. Typical tasks include geological surveying and data gathering in environments where the use of unmanned untethered vehicles is mandatory [6]. Autonomous marine vehicles have long been regarded as a game-changer in the exploration and exploitation of the ocean. The key to their acceptance is consistent access to remote and dangerous locations for data collection and intervention, which is made possible by their autonomy. While autonomous underwater vehicles have long been the focus, unmanned surface vehicles are also being developed and used at an increasing rate [1].

2. FOULING PATTERN

2.1 Types and categories in fouling

According to [4], the fouling is categorized into three parts: soft, hard, and composite. Soft fouling, such as algae, slime, and grasses, has little impact on the ship's coating systems and performance. Hard fouling has a sedimentary structure, making it more persistent and potentially harmful to the ship's and coating systems' function. Composite fouling has a major impact on the ship's performance, as well as the ship's coating and mechanical systems. Fig. 1 shows the hull covered in bio-foul.

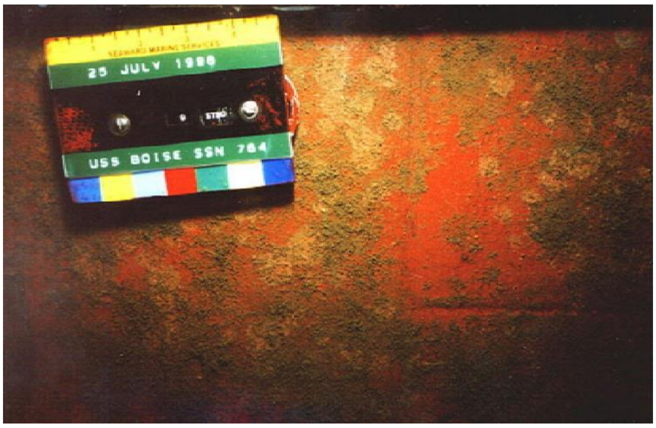

Fig -1: FR-20, Over 80 Percent of area covered in bio-foul

- Slime—The Formation of slime is the first step in the fouling process. The coating of slime is smooth and generally follows hull contours [4].
- Grass and other soft fouling—Grass is a form of multicellular green and brown algae. It forms most heavily near the water-line, where adequate light is available for photosynthesis [4].
- Hard fouling—Dominant organisms in this stage of fouling are barnacles (usually acorn) and tubeworms [4].

2.2 Fouling Rating (FR) scale

Each of the ten fouling patterns has been assigned a rating number on a range of 0 to 100 in 10-point increments. The lower the number, the cleaner the hull, and the higher the number, the more fouling organism populations there are, and the more diverse and severe they are [4].

3. AUTOMATED HULL CLEANING ROBOT DESIGN

3.1 Mechanical Design of the Robot

Fig. 2 depicts the design for the ship hull cleaning underwater robot. The underwater robot utilizes fins to go through water while inspecting the ship's hull and cleaning it.

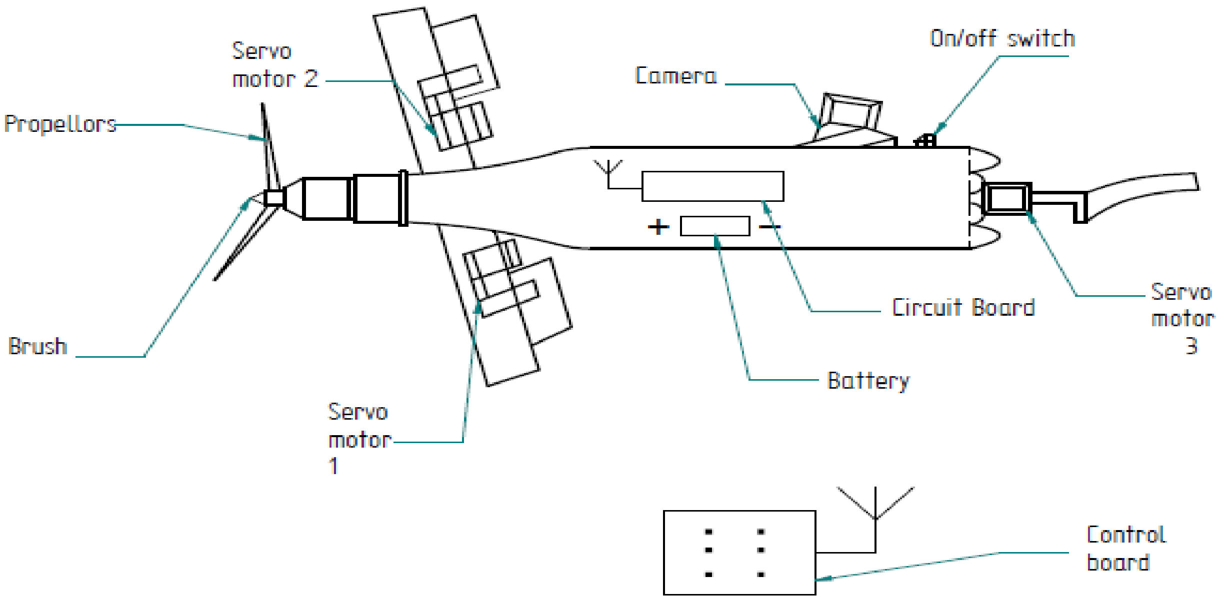

Fig -2: Design of automated hull cleaning robot

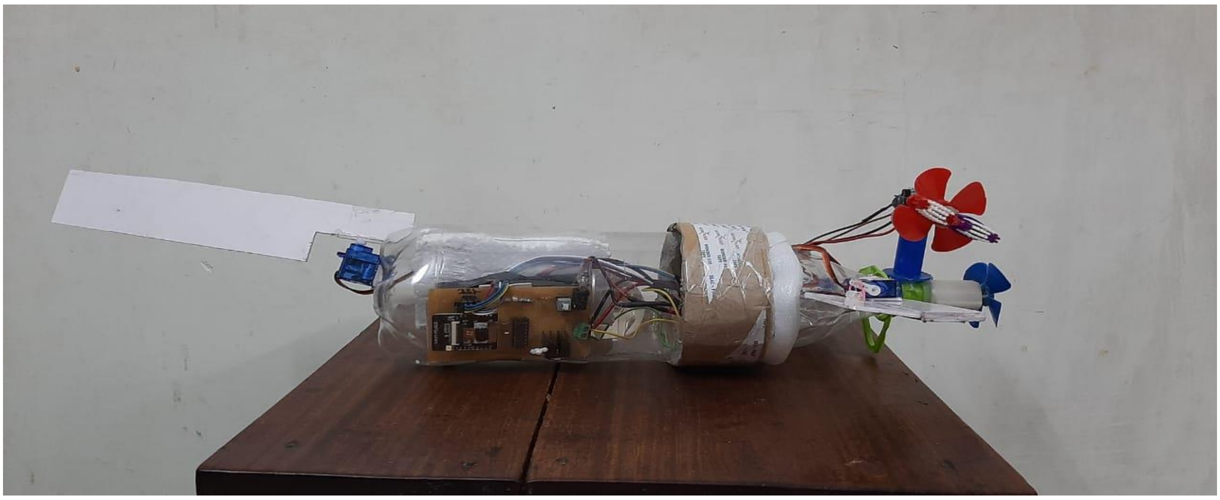

Fig -3: Prototype model of the automated hull cleanig robot

The robots consists of a main-cylinder including control circuits and communication devices, 3 fins, a brush unit for cleaning, a camera module, and a propeller for its movement under water. A battery that is used to power up the circuit, and the circuit board are placed inside the cylinder (bottle?). The ESP 32 CAM module is inside the cylinder. A push button is also placed to turn on/off the robot. 2 servomotors are placed in the peripheries of the robot and the one servomotor at the tail end. BLDC Motor is placed in the front end, which is connected to the propellers. Fig. 3 shows the prototype model of the hull cleaning robot.

3.2 Hardware Components Used

- **ESP32 CAM Module**: The ESP32 CAM Wi-Fi Bluetooth development with OV2640 camera module based on the ESP 32 chip with the additional facility of using a camera. This is a wireless monitoring and live streaming module. The robot carries a camera to transmit a live feed of its surroundings to the user. Camera is used for live monitoring of the surface of the hull. Fig. 5 shows the live monitoring of the hull.
- **Servo motor- SG 90:** Servomotors are used to change the movement of the fins in order to change the direction of the robot. By changing the angular or linear positions, for specific positions, the robot moves inside the water. It is a Digital Servo Motor that receives and processes PWM signal faster and better.
- **Brushless DC Motor – A2212**: Due to its high torque and high efficiency, it is used for the rotation of the brushes which are in turn used for the cleaning of the hulls. A2212 brushless out-runner motor specifically made to power quad-copters and multi rotors. It is a 1000KV motor. It provides high performance super power and brilliant efficiency.

Fig -4: Hull cleaning robot under water

- **L293D Motor Driver**: Motor require high amount of current whereas the controller circuit works on low current signals. So the function of motor drivers is to take a low-current control signal and then turn it into a higher-current signal that can drive a motor.
- **Lithium-Polymer Battery:** This is used to power the circuit. It has high conductivity and provides high specific energy. BLDC motor is powered up

using this Li-Po Battery for its high torque and high current. It is of the capacity of 2000mAh.

- **9V Battery:** This provides constant 9V output till it lasts. It has a metal jacket body hence it is leak proof.

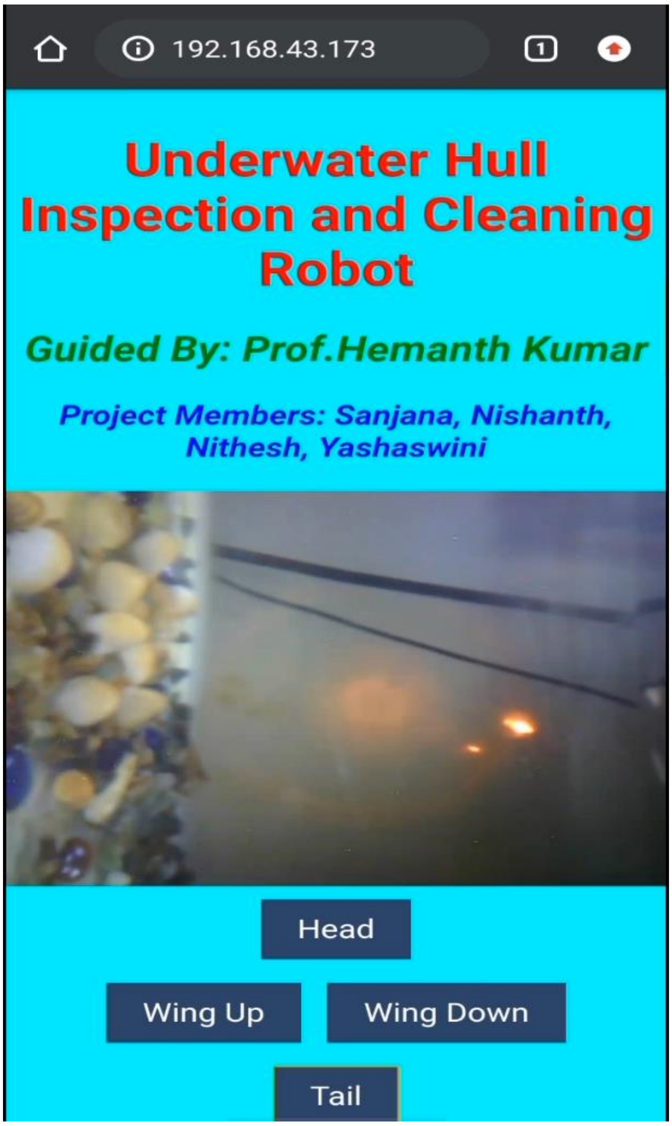

Fig -5: Live monitoring of the condition of the hull

4. RESULTS AND CONCLUSION

The robot is sent into the water for hull inspection. The robot can clean the hull using brushes connected to it. The movement of the robot is through the servomotors attached to the adjacent fins of the robot controlled by the user through a Wi-Fi connection to the ESP 32 CAM module. The camera module transmits the image into our devices (mobile phones), and we can inspect the area around the hull which is covered in bio-foul, which is shown in fig. 5. The detected bio-foul is then removed using a brush.. The brush is connected to a high torque motor (BLDC Motor). The movements of the motor is controlled using a Wi-Fi network through an IP address and at the rear end to navigate horizontally and BLDC motor. A snapshot of the underwater hull cleaning robot is shown in the fig. 4

For the robot to move inside the water, BLDC motor aids this action and for both vertical and horizontal motions, servomotors are used. There are servomotors attached to the peripheries of the robot. Fins are connected to these servomotors which help in the movement of the robot. This concerns with the vertical movement of the robot. For horizontal movement, additional servomotor is fixed in the rear end of the robot, which is connected to a fin. After cleaning away the bio-foul, we can then bring back the robot to the shore using the Wi-Fi control.

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