DESIGN AND FABRICATION OF RC SOLAR LAKE/POOL CLEANER DRONE

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Thesis submitted to the faculty of Engineering, CECOS University of IT & Emerging Sciences in partial fulfillment of the requirements for the degree of B.Sc. Mechanical Engineering

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June, 2023

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"DESIGN AND FABRICATION RC SOLAR LAKE/POOL CLEANER DRONE"

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Abstract

The increasing concern for water pollution and the need for sustainable solutions have prompted the development of innovative technologies in the field of water treatment and management. This thesis focuses on the design, development, and implementation of a solar-powered lake/pool cleaner drone, capable of removing debris and pollutants from water bodies. The research begins with a comprehensive analysis of water pollution and the limitations of existing cleaning methods. The concept of a mobile-controlled drone is introduced, allowing users to remotely navigate and control the drone's cleaning operations using a mobile application. The drone's design incorporates pH and turbidity sensors, enabling real-time monitoring of water quality.

This work also focuses on the integration of solar power technologies, enabling the drone to operate for extended periods. Solar panel are strategically placed on the drone's body to harness renewable energy and ensure sustained cleaning operations without the need for external power sources.

Field trials are conducted to evaluate the performance of the solar lake/pool cleaner drone. The trials assess its ability to accurately measure pollution levels using the pH and turbidity sensors, as well as its efficiency in debris collection through rudderless operation. The results demonstrate that the mobile-controlled drone offers a practical and user-friendly solution for monitoring and cleaning water bodies.

In conclusion, the solar lake/pool cleaner drone presents a promising approach to tackle water pollution. Its mobile-controlled functionality, coupled with pH and turbidity sensors and rudderless operation, makes it a versatile and efficient tool for pollution monitoring and debris collection in lakes and pools.

Keywords: *Solar Lake cleaner, pool cleaner, drone, mobile control, pollution monitoring, debris collection*

Dedications

"Dedicated to our beloved parents who prayed day and night for our success and provided us every opportunity to achieve our goals"

Acknowledgement

All thanks and gratitude's are due to Almighty ALLAH, the most beneficent, the expediter, the cherisher, the nourisher, and the sustainer and the most gracious whose blessings enabled us to complete this project

We would like to thank Dr. Muhammad Shakeel for his sincere and invaluable assistance, recommendation and supervision

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1. INTRODUCTION

Drones, generally known as unmanned aerial vehicles (UAVs), are small remote-controlled aircraft that are typically used for surveillance, inspection, and mapping. Drones are capable of capturing high-resolution photos and videos from a bird's eye view, making them an incredibly versatile tool in many different fields [1].

When it comes to water, drones can be used for a variety of purposes. For example, they can be used to assess the health of coral reefs, track marine mammals, and monitor the movement of ocean currents. In addition, drones are increasingly being used by researchers to gather data on the impact of climate change on the world's oceans.

Drones that are specifically designed for use on water are usually referred to as unmanned surface vehicles (USVs). These can be used for tasks such as mapping the ocean floor, collect water samples for analysis, and monitoring the spread of harmful algae blooms. USVs can be equipped with a range of sensors, including cameras, sonar, and temperature probes, making them a powerful tool for scientific research and other applications in the maritime industry [2].

1.1 Why drones:

From the Federal Aviation Administration (FAA), define a drone as:

“Drones are unmanned aerial vehicles or systems, which are often operated remotely or autonomously, and can perform a variety of tasks without human onboard.”

Drones have become popular for a variety of reasons - from their ability to capture stunning aerial footage, to their usefulness in various fields such as agriculture, construction, surveying, and disaster response. They have the ability to operate in difficult-to-reach or hazardous areas, and can provide real-time information and inspections that were once impossible or took a lot of time and effort [3].

Drones have many benefits that make them a valuable tool across a variety of industries.

- They can save time and money
- Improve efficiency
- Provide valuable insights and information
- Make dangerous tasks safer and easier to perform.

Drones can collect large amounts of data quickly and accurately. They have the ability to be used in aerial photography and videography, search and rescue, agriculture, oceans, lakes and pools, inspection and maintenance, transport, mapping and surveying. Due to these uses drones are highly advance device and have a great demand in the industries and societies [3].

1.2 RC Solar Lake/pool Cleaner Drone:

Solar lake pool cleaner drone is designed to automatically clean and maintain swimming pools, lakes, and other bodies of water using solar power. The drone is equipped with a set of components which is used to remove debris, cleans surface of water from solid wastes and algae. The drone's movement is powered by a solar panel that operates in conjunction with onboard batteries. The main advantage of using a solar-powered pool or lake cleaning drone is that it is much more environmentally friendly and cost-effective than traditional pool cleaning methods. Additionally, it can be programmed to clean the water on a regular basis, improving overall water quality and reducing the need for manual cleaning [4].

There are different types of solar-powered water cleaning drones available in the market, and new designs and concepts are constantly emerging. Here are a few main types:

1. Surface Skimmers: Solar-powered surface skimmers operate on pool surfaces, skim surfaces and collect debris. It avoids clogging and improves the pool's water quality [4].

2. Deep Cleaners: These drones are designed to clean the pool floor and walls. They have scrubbers underneath them which removes visible dirt, dead algae, and bacterial colonies [4].

3. Combo drones: These machines provide all the functionalities of the above two types. It can skimmer and scrubber, helping the user with varied functionalities [5].

Solar-powered water cleaner drones are also available for ponds, lakes, and other large water bodies. They have more robust designs and efficient motors to handle the depth and volume of such water bodies [5].

1.3 Problem Statement:

Polluted lakes and pools are the result of the contamination of water sources by substances which make the water unusable for drinking, cooking, cleaning, swimming, and other activities. The major issues with cleaning Lakes and Pools are:

- Finding/hiring motorized boats each time for cleaning.
- 2 People team – 1 for driving other for collecting trash.
- Not being able to clean regularly due to manual process.
- Higher salary and motor boat costs involved of cleaning.

Therefore, this project will be focus on a Solar Lake pool cleaner drone which is an advanced device for cleaning the lakes and pool and will solve all issues regarding cleanness of water. It is seen as a desirous product in the market. Quick, reliable, and easy features are significant factors that boost product demand in the industry.

1.4 Aims:

The aim of this project is to effectively and efficiently clean the pool or lake, improving the water quality and creating a healthier environment for swimming or other aquatic activities. Some common aims of this project are as follows:

- The project aims to remove all kinds of debris ranging from leaves and twigs to small dust particles and other contaminants accumulating in the water. This helps in maintaining a clean and visually appealing water body.
- Algae can quickly spread in still or stagnant water, causing harm to the aquatic life and making the water hazardous for swimming. This project will help in prevent algae growth and remove the existing algal bloom and spores from the water.

- It will also help bolster water circulation within the pool or lake, ensuring that the pool is healthier to swim in.
- This project will rely on solar panels to generate the necessary electrical energy, making them eco-friendly, efficient, and low-cost.
- This project will minimize time and cost for pool or lake maintenance, as the need for hiring external labor for cleanup is reduced.

1.5 Objectives:

To design and fabricate a radio controlled solar propelled lake/pool cleaner drone

1.6 Scope of the study:

This study will focus on the design, manufacturing and testing of an efficient solar propelled drone which will be controlled through radio links. The drone will be capable of collecting all debris ranging from leaves and twigs to small dust particles and other contaminants accumulated in the water.

This drone utilizes 2x High torque motors, RC Controller, Solar Panels, 2x Sensors, collector mesh and at a mega microcontroller to achieve this task. The dual drive rudderless motor system is used to provide drive to the RC boat using dual propulsion system. This allows for an easy rudderless movement control.

The collector mesh is enclosed inside the RC boat frame to capture surface garbage floating on water. This allows the drone to swallow all the garbage coming in its path and take it ahead. Any sea creatures caught along with the garbage may easily swim out of the mesh through front opening if caught, thus it doesn't harm any sea life.

The RC controller is used to send movement controls to the drone controller unit via RF signals from Bluetooth module. These signals are received and decoded by the controller unit (Arduino UNO) and then processed by microcontroller to operate drive motors. The drone uses 2x sensors (pH and turbidity) to sense and pH and turbidity level of water pollution.

The top mounted solar panels are used to draw solar power and constantly charge the battery as the drone operates. Even if the drone shuts down in the middle of the lake. Half an hour of sunlight can again make the robot operational again. This allows for a remotely operated long range lake pool cleaner drone.

1.7 Thesis Outline:

This thesis consists of five chapters. Chapter one explains the introduction of the project including aims, objective and scope of this project. This chapter also mentions the problem statement and general project information.

Chapter two covers the literature review and previous studies on topics that are related to the project. It covers both, universities research and implementations by other companies or organizations that are related to Solar Lake/pool cleaner drones.

Chapter three will cover the methodology of the project. The main topic of this chapter will describe the three most important subjects and there are hardware designing, electronic and circuit designing and programming using suitable microcontroller software.

Chapter four illustrates the result and discussion on the project after the project complete and finally chapter 5 summarized the project in all field.

2. LITERATURE REVIEW

This chapter provides the summary of literature reviews on topics related to solar lake/pool cleaner drone that has the capability to survey the environment.

2.1 Manual cleaning techniques for water:

Manual processes used for water cleaning and swimming pool cleaning vary depending on the specific needs and resources available. Here are some common manual methods used for water cleaning:

1**. Skimming:** Skimming involves using a net or skimmer to remove debris such as leaves, insects, and other floating materials from the water surface. The problems with this method are:

- Labor-intensive: Skimming large pools or bodies of water can be time-consuming and physically demanding.
- Limited reach: Skimmers can only collect debris on the water surface and may not reach corners or tight spaces [6].

2. **Vacuuming:** Vacuuming is performed using a manual vacuum head attached to a pool pole, connected to a suction line or a portable vacuum unit. It features:

- Time-consuming: Vacuuming large pools can be a time-consuming process, especially if the pool has a significant number of debris or sediment.
- Labor-intensive: The person performing the vacuuming needs to manually maneuver the vacuum head across the pool, which can be physically demanding.
- Limited effectiveness: Manual vacuuming may not effectively remove all debris and sediment, particularly in hard-to-reach areas.[6]

3. **Chemical treatment:** Manual chemical treatment involves adding various chemicals, such as chlorine, algaecides, and pH adjusters, to maintain water quality. It includes:

- Health hazards: Improper handling of chemicals can pose health risks to the person performing the treatment, and overexposure or incorrect dosage can lead to adverse effects on swimmers.
- Frequent monitoring and adjustment: Manual chemical treatment requires regular testing of water parameters and adjustments to maintain the desired balance. This can be time-consuming and require expertise.
- Limited effectiveness: Chemical treatment may not effectively address certain water quality issues, such as high levels of dissolved minerals or persistent algae growth.[6]

2.2 Revolutionizing water cleaning:

Water cleaning techniques for solid waste have undergone significant advancements, revolutionizing the way we address and manage waste in water bodies.

2.2.1 Screens:

Screens: Screens, such as trash racks or litter traps, are physical barriers installed in waterways to capture larger solid wastes. However, they may allow smaller particles and dissolved contaminants to pass through, limiting their effectiveness in comprehensive waste removal [7].

2.2.2 Sedimentation and Settling Tanks:

Sedimentation: Sedimentation involves allowing water to sit undisturbed, allowing gravity to settle suspended particles and solid waste. However, this technique is not effective for removing dissolved pollutants and may require significant space and time for the sedimentation process to occur. Additionally, frequent maintenance is necessary to remove accumulated sediments and maintain tank efficiency.

Settling Tanks: Similar to sedimentation, settling tanks promote the settling of solid wastes, allowing cleaner water to overflow or undergo further treatment. However, these tanks may have limitations in terms of their capacity and may require regular cleaning to prevent clogging and maintain effectiveness [8].

2.2.3 Waste Traps and Catchment Systems:

Waste Traps: These devices, installed in drainage systems or outlets, capture solid waste before it enters water bodies. While they are effective at trapping larger debris, waste traps may require regular maintenance to prevent blockages and need to be strategically placed to capture waste efficiently.

Catchment Systems: Catchment systems collect and divert surface runoff, capturing solid waste and preventing its entry into water bodies. However, their effectiveness may be limited by the size and design of the catchment area, and they require regular maintenance to prevent overflow and ensure proper functioning [9].

2.2.4 Ferry boat water cleaning system:

Ferry boats, in relation to water cleaning, primarily serve as a means of transporting personnel, equipment, and materials for water cleaning operations. They play a role in maintaining and improving water quality through various activities such as:

- Ferry boats can be utilized to collect floating debris, such as litter, logs, and other pollutants, from water bodies, preventing their accumulation and potential harm to marine life. Ferry boats equipped with monitoring equipment can facilitate the collection of water samples from different locations for analysis. This helps assess water quality parameters such as temperature, pH, dissolved oxygen levels, and pollutant concentrations. In certain cases, ferry boats can be fitted with equipment such as nets or cutters to remove excess algae, weeds, or invasive aquatic plants, preventing their overgrowth and maintaining a balanced aquatic ecosystem [10].
- Ferry boats may have limitations in effectively covering large water bodies or reaching inaccessible areas such as narrow channels, shallow waters, or densely vegetated regions. Ferry boats may require specialized equipment and trained personnel for effective water cleaning operations, adding to the operational costs and logistical requirements. The use of ferry boats for water cleaning activities needs to be carefully managed to minimize potential disturbances to sensitive habitats, wildlife, and protected areas [10].

2.2.5 Quadrotors water cleaning system:

Quadrotor equipped with water cleaning systems have emerged as innovative tools for addressing water pollution. These drones are designed to perform various water cleaning tasks efficiently.

- Quadrotors can be equipped with skimming devices to collect floating debris, such as plastics, leaves, and other pollutants, from the water surface. They can navigate over water bodies, collecting and storing the waste in onboard compartments. It can carry water sampling equipment to collect samples from different locations for analysis. This helps assess water quality parameters and detect pollution sources or contaminants. Quadrotors can be equipped with sensors and cameras to capture aerial images, monitor water conditions, and detect changes in water quality. This allows for efficient monitoring of large water bodies or inaccessible areas. Drones can be equipped with specialized sensors and imaging systems to detect algal blooms or excessive growth. This enables early detection and targeted control measures to prevent ecological imbalances [11].
- Quadrotors have a limited payload capacity, which restricts the amount of waste they can collect and carry. Frequent returns to a collection point or vessel may be necessary for unloading the waste. Quadrotors are sensitive to weather conditions, particularly wind and rain. Strong winds can make flight challenging, and rain or water splashes can affect their electronic components and sensors. The use of drones for water cleaning must comply with local regulations and airspace restrictions. Safety protocols need to be followed to prevent accidents, such as collisions with people, wildlife, or other objects [11].

3. DESIGN OF RC SOLAR LAKE/POOL CLEANER DRONE

This chapter discusses the methods and materials employed in the design and fabrication of the project, as well as its manner of operation.

3.1 Design of RC solar lake/pool cleaner drone:

To build the solar lake/pool cleaner drone (unmanned surface vehicle), several specifications need to be defined in order for the drone to fulfill its requirements. Our designed solar lake/pool cleaner drone incorporates twin propulsion motors with propellers in order to move the drone in the water. The pH sensor is placed at the back of the drone that has capability to check the acidic or basic nature of the water. This project also uses the turbidity sensor in order to measure the amount of light that is scattered by the suspended solids in water. It simply detects the particles that are suspended in water.

3.1.1 Mechanical Design:

A range of concepts were initially generated and evaluated. After a thorough brainstorming and based upon the functionality and performance, the present design of the drone cleaner was finalized. For CAD modelling this project uses PRO-E because the software is easy to use for basic user. PRO-E is a 3D modelling program designed for architects, civil engineers, filmmakers, game developers, and related professions. The use of this software enables people to illustrate their design in three-dimension form and capable to adapt the design to the real component. Figure 3.1 shows the main window of PRO-E before the mechanical drawing design precede. The generated 3D model is depicted in Figure 3.2.

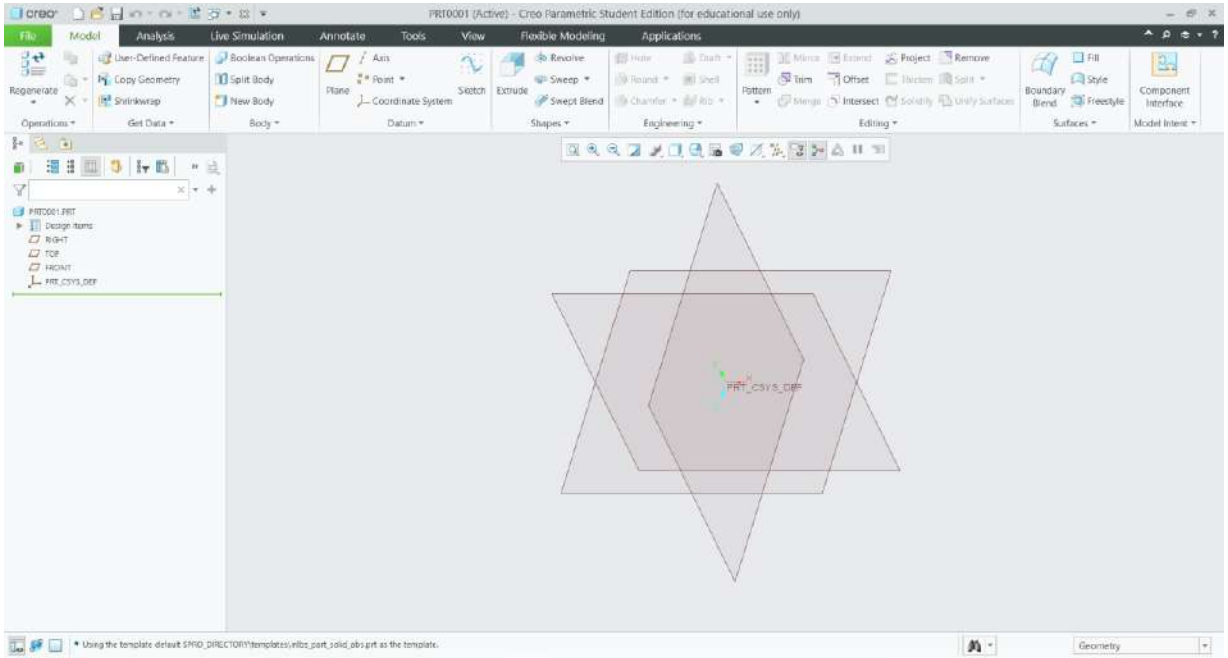

Figure 3.1: The front page of PRO-E

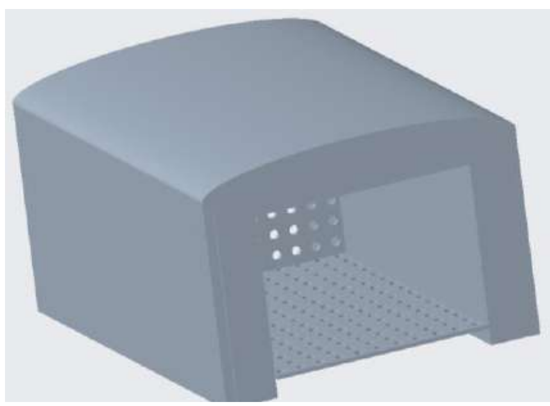

Figure 3.2: 3D model of the solar lake/pool cleaner drone

3.1.2 Material Selection:

A range of materials were considered for the manufacturing of the cleaner drone. For the main body of the system, **aluminum composite panel (ACP)** is selected based on its suitability for this specific system. The ACP is a sandwich-like structure consisting of two thin aluminum sheets bonded to a core material, typically made of polyethylene (PE) or fire-retardant mineral core. The aluminum sheets provide durability, corrosion resistance, and aesthetic appeal, while the core material enhances the panel's strength and insulation properties. ACP is widely used in construction for facades, signage, and interior applications due to its lightweight nature and versatility.

Stainless steel is used in mesh which offers high strength, durability, and excellent corrosion resistance. The mesh is commonly used for various applications such as filtration, security screens, insect screens, and reinforcement. In the context of a submersible solar water cleaner drone (USV), stainless steel mesh can be employed as a protective barrier to prevent debris or large particles from entering the drone's sensitive components while allowing water to pass through.

Thermocol, also known as expanded polystyrene (EPS), is a lightweight, rigid foam material with excellent thermal insulation properties. In the context of a submersible solar water cleaner drone USV, thermocol can be used to provide buoyancy and maintain the drone's flotation. By incorporating thermocol into the drone's structure, it can stay afloat while carrying out its cleaning operations underwater.

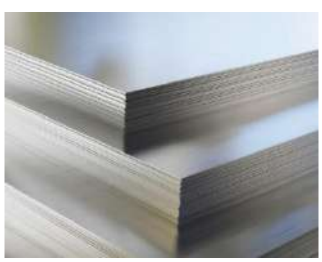

Figure 3.3: Stainless Steel

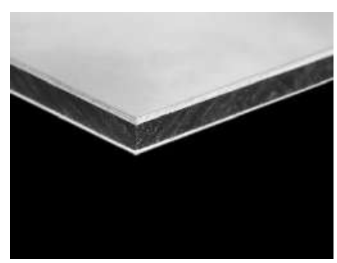

Figure 3.4: Aluminum composite panel

Figure 3.5 Thermocol

3.1.1 Finite Element Analysis (FEA):

Finite Element Analysis (FEA) is a powerful numerical method used to simulate and analyze the structural behavior of complex systems. It is widely employed in engineering and design to predict how a structure or component will respond to various loading conditions. ANSYS software, a leading FEA software package, provides advanced capabilities for conducting such analyses. ANSYS offers a comprehensive suite of tools for solving a wide range of engineering problems, including structural, thermal, fluid, electromagnetic, and Multiphysics simulations. It utilizes the finite element method, which divides the geometry of a structure into smaller finite elements, allowing for the accurate representation of complex shapes and varying material properties. Figure 3.6 shows the front page of ANSYS workbench.

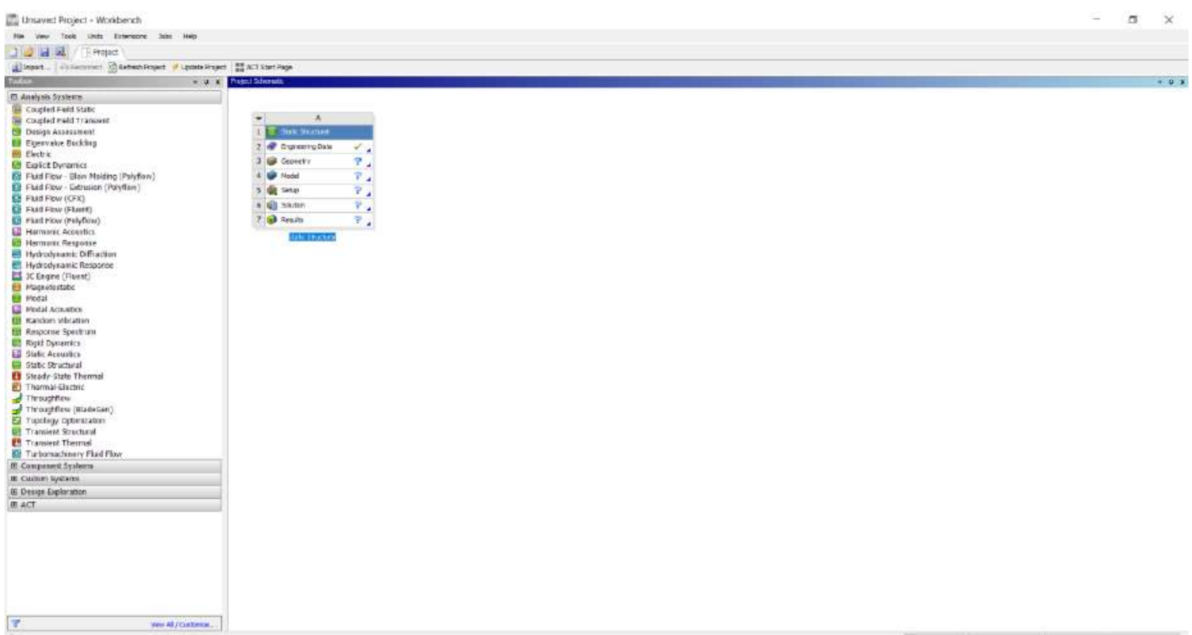

Figure 3.6 ANSYS Workbench front page

FEA with ANSYS software enables engineers and designers to make informed decisions during the product development process. It helps identify potential design flaws, optimize designs, evaluate material selection, and ensure structural integrity.

By simulating the real-world behavior of a system, engineers can save time and resources by reducing the need for physical prototypes and testing.

In this case, we performed FEA on the mesh structure of a solar lake/pool cleaner drone using ANSYS software, we have selected material i.e., stainless steel 22-gauge sheet for mesh.

The main objective of the analysis is to determine the normal stresses generated in the drone mesh structure due to the hydraulic pressure of water impacting on it.

To perform the analysis, we followed the following steps:

1. Geometry and Mesh Generation:

First of all, we have Import a 3D model of the drone mesh from PRO-E in the ANSYS software, considering its actual dimensions and shape. After that we have generate a suitable mesh for the model, ensuring appropriate element size and mesh density to capture the structural behavior accurately. The mesh should be refined around areas where high stress concentrations are expected, such as edges and connections.

2. Material Properties:

After that we have define the material properties for stainless steel B30 grade 22-gauge sheet. These properties include Young's modulus which is 967GPa, Poisson's ratio is 143, and yield strength is 577MPa, which can be obtained from material specifications or material testing data.

3. Boundary Conditions:

After that we have apply appropriate boundary conditions to simulate the real-world scenario. For this analysis, we assume fixed supports on the drone mesh and apply the load by defining the hydraulic pressure of water impact on the mesh as shown in figure 3.7.

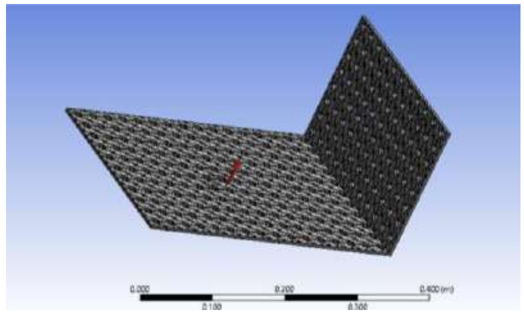

Figure 3.7: Applied boundary conditions on mesh

4. Analysis Setup:

After that specify the type of analysis as static analysis, as we are interested in studying the structural behavior of the mesh under a steady load. We have defined appropriate solver settings, such as convergence criteria and solution methods.

5. Solution:

After that, run the analysis and let the software solve the equilibrium equations based on the applied loads and boundary conditions.

6. Results and Post-processing:

After the analysis is complete, we have examined the results to determine the generated normal stresses on the mesh. ANSYS provides various post-processing tools to visualize and analyze the results.

By performing the finite element analysis using ANSYS, we will be able to obtain a detailed understanding of the normal stresses generated on the solar lake/pool cleaner drone mesh structure due to the hydraulic pressure of water impact. The stress analysis had helped us to evaluate the structural integrity of the mesh and make necessary design improvements if required. As figure 3.7 and 3.8 shows the stresses generated on the mesh. Figure 3.9 shows the chart from minimum to maximum stresses generated.

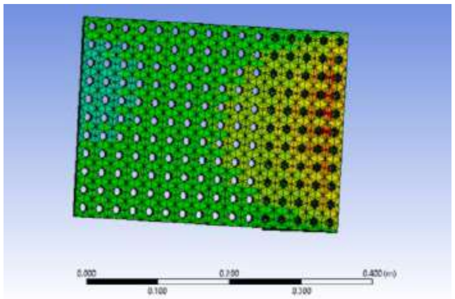

Figure 3.8: Mesh bottom view

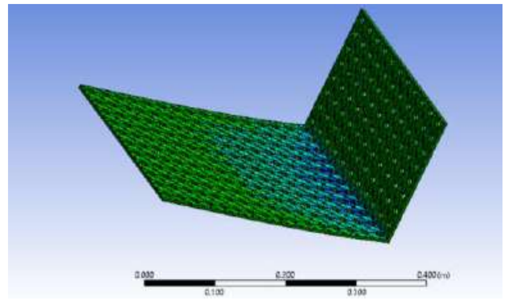

Figure 3.9: Mesh side view

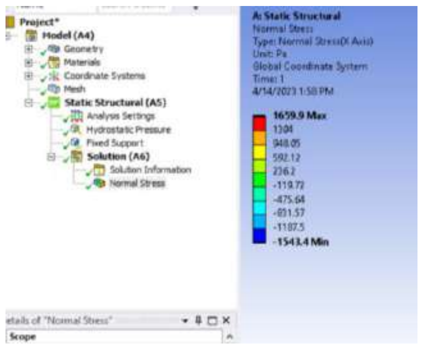

Figure 3.10: The Chart shows minimum to maximum stresses generated on mesh

3.2 Design of Electronics Components:

Following are the design of electronics components which are used in the solar lake/pool cleaner drone.

3.2.1 Underwater thruster motors:

This solar lake/pool cleaner drone is fitted in with two underwater thruster motors for the movement of the drone.

Figure 3.11: DC Underwater thruster motors

The DC underwater thruster motors are used to move the drone in any direction. Whenever the drone comes against an obstacle, the right motor will stop and the left motor will move the drone away from the obstacle and will keep it moving forward. The movement of these thruster motor will be controlled through remote control mechanism. Figure 3.6 shows the DC underwater thruster motors.

3.2.2 Arduino UNO and Bluetooth module:

The Arduino UNO is a microcontroller board that serves as the brain of the solar lake pool cleaner drone. It receives commands and controls the drone's various components. The Bluetooth module acts as a wireless communication interface between the drone and a remote device, such as a smartphone or tablet.

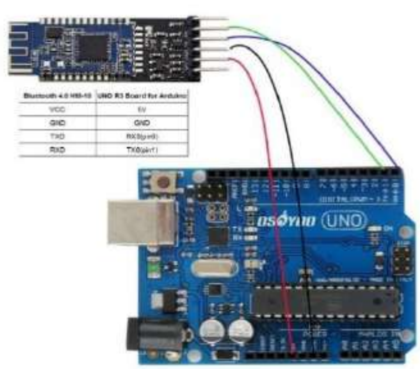

Figure 3.12: Arduino UNO with Bluetooth module

The Arduino UNO is programmed to process input from sensors, such as pH and turbidity sensors and control the drone's movements accordingly. It manages the motor controllers that control the propulsion system of the drone.

The Bluetooth module enables the drone to receive commands and transmit data wirelessly. It allows the user to remotely control the drone's functions, such as starting or stopping the cleaning process and receiving feedback or status updates from the drone. The module facilitates bidirectional communication between the drone and the remote device, providing a convenient and flexible control interface for the user. The Arduino UNO and Bluetooth circuit is shown in Figure 3.7 while its illustrative circuit diagram is depicted in Figure 3.8.

Schematic Diagram:

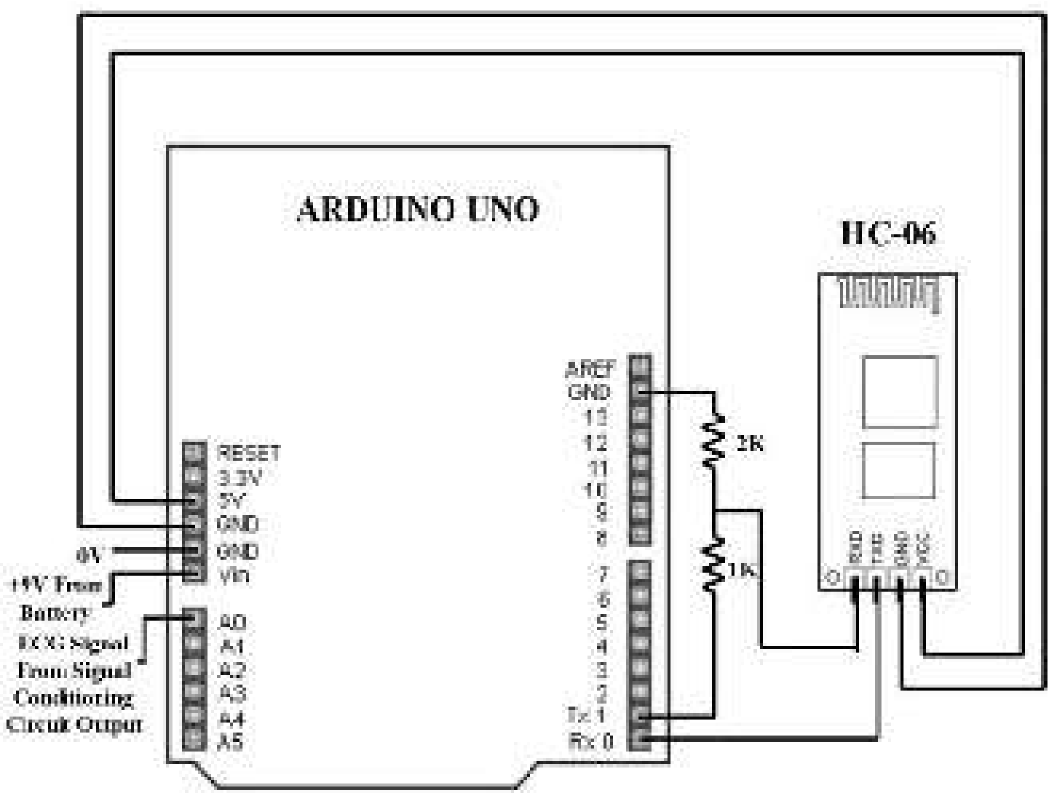

Figure 3.13: Arduino UNO and Bluetooth circuit attachment

3.2.3 12v Battery (6000mah):

The 12V battery with a capacity of 6000mAh (6Ah) and a discharge rate of 30A provides power to the solar lake pool cleaner drone and is shown in Figure 3.9. The battery acts as an energy storage device, supplying electrical power to the various components of the drone.

Figure 3.14: 12V battery (6000mah)

When the drone is operational, it draws power from the battery to operate its motors, sensors, and other electronics. The discharge rate of 30A indicates the maximum continuous current that the battery can provide without being damaged.

To charge the battery, a charging system capable of delivering a current of 5A is used. The charging system takes electricity, typically from a solar panel or a power outlet, and converts it to the appropriate voltage and current required for charging the battery. The 5A charging current means that the battery can be charged at a rate of 5 Amps, which determines the speed at which the battery can be recharged.

3.2.4 Solar Panel:

The solar panel in the solar lake pool cleaner drone serves as a source of renewable energy to power the drone's electrical systems. It utilizes photovoltaic (PV) technology to convert sunlight into electrical energy.

Figure 3.15: Solar panel mounted on lake/pool cleaner drone

The solar panel is composed of multiple interconnected solar cells, which are wired in series or parallel to achieve the desired voltage and current levels. The generated electrical energy from the solar panel is typically in the form of direct current (DC) and can be used to power the drone's components directly or charge a battery for later use.

In the solar lake pool cleaner drone, the solar panel is usually mounted on top of the drone's body to maximize exposure to sunlight as shown in Figure 3.10. As the drone operates on the water's surface, the solar panel harnesses sunlight and converts it into electrical energy to power the drone's motors, sensors, communication systems, and other electronic components.

The solar panel allows the drone to operate for extended periods without solely relying on external power sources or frequent battery replacements. It contributes to the drone's sustainability by utilizing clean, renewable energy from the sun to reduce its environmental impact and enhance its autonomy.

3.2.5 Electronic Speed Controllers:

The electronic speed controller (ESC) in the solar lake pool cleaner drone is responsible for controlling the speed and direction of the drone's motors. It acts as an interface between microcontroller and the motors.

The ESC receives signals from the microcontroller that indicate the desired speed and direction for each motor. It then adjusts the voltage and current supplied to the motors accordingly to achieve the desired rotational speed and direction.

Additionally, the ESC may incorporate other features such as motor protection mechanisms, which monitor parameters like temperature and current to prevent damage to the motor and ESC.

Figure 3.16: 30A Electronic speed controller

Overall, the ESC plays a crucial role in translating the control signals from the microcontroller into precise motor control, enabling the solar lake pool cleaner drone to maneuver, change speed, and perform its cleaning tasks effectively and efficiently. A typical ESC is shown in Figure 3.11.

3.2.6 Sensors:

A sensor is a device or component that detects and measures physical or environmental changes and converts them into an electrical or digital signal. Sensors can sense a wide range of phenomena, including temperature, pressure, light, motion, proximity, sound, humidity, and more. They are designed to interact with the surrounding environment and capture specific data or information. Sensors are utilized in various applications, such as industrial automation, consumer electronics, healthcare, environmental monitoring, and robotics, enabling systems to gather real-time data and respond accordingly to optimize performance, enhance safety, and enable intelligent decision-making.

This project uses pH sensor which is a device that measures the acidity or alkalinity of a solution by detecting the concentration of hydrogen ions. It provides a numerical value known as pH, which indicates the solution's level of acidity (pH < 7) or alkalinity (pH > 7). The pH sensor typically consists of a sensing electrode that responds to changes in hydrogen ion concentration and generates an electrical signal proportional to the pH value. This information is used in various applications, such as water quality monitoring, chemical analysis, agriculture, and industrial processes, to ensure optimal conditions or make necessary adjustments based on pH levels.

There are two sensors used in this project. First is the pH sensor which will detect the acidic or basic nature of the water and second is the turbidity sensor which is used to measure the cloudiness or opacity of a liquid. It detects and quantifies the number of suspended particles or solids present in the liquid, which can affect its transparency. Turbidity sensors are commonly used in water quality monitoring, environmental analysis.

- **pH Sensor:**

The pH sensor in a solar lake/pool cleaner drone USV (Unmanned Surface Vehicle) works by measuring the concentration of hydrogen ions in the water. The pH sensor typically consists of a glass electrode and a reference electrode immersed in the water. The glass electrode generates a voltage that is proportional to the pH level of the water. This voltage is then converted into a pH value by the drone's onboard electronics and will display the reading on the screen present on the drone, which receives the pH readings. So, it analyses the pH data and make decisions based on the desired pH range for effective cleaning or water treatment.

By continuously monitoring the pH level, it can be ensured from the screen that the water's acidity or alkalinity remains within the target range, maintaining optimal conditions for cleaning and water quality. The pH sensor enables the drone to provide efficient and automated cleaning while facilitating effective maintenance of the lake or pool's water chemistry. Figure 3.12 shows pH sensor which is connected to the back of the drone; its schematic diagram is shown in Figure 3.13.

Figure 3.17: pH sensor

Schematic Diagram:

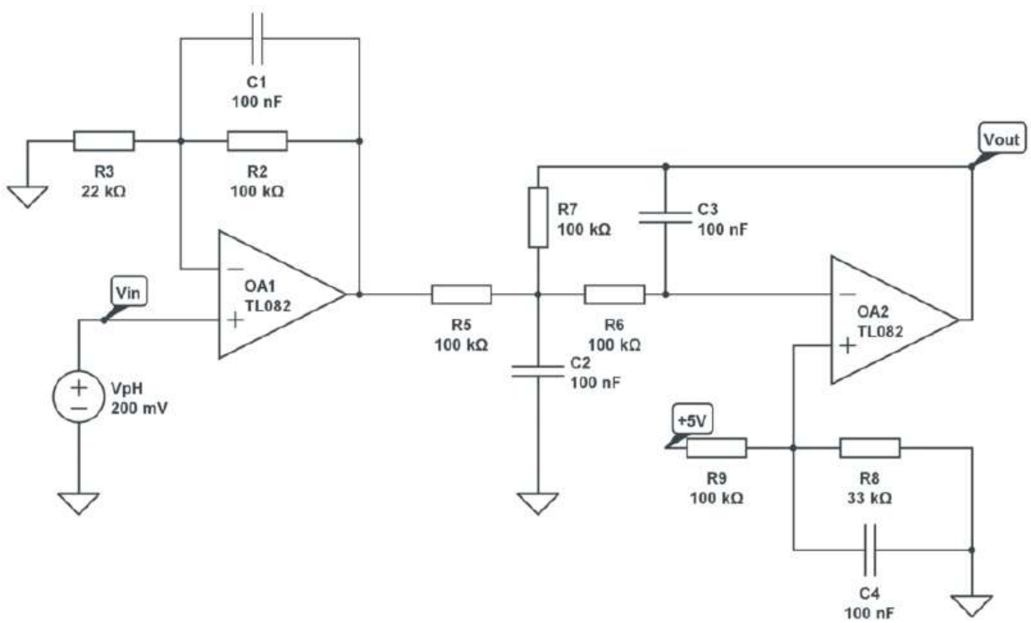

Figure 3.18: pH sensor circuit arrangement

- ## Turbidity Sensor:

The turbidity sensor in a solar lake pool cleaner drone USV detects and measures the number of suspended particles or solids in the water. It uses a light source and a detector to assess the scattering or absorption of light caused by the particles in the water. By analyzing the intensity of the light received by the detector, the turbidity sensor determines the water's turbidity or cloudiness. This information helps the drone assess the cleanliness of the water and make appropriate adjustments to its cleaning parameters for optimal performance. Figure 3.14 shows the turbidity sensor used in our project while Figure 3.15 shows its schematic diagram.

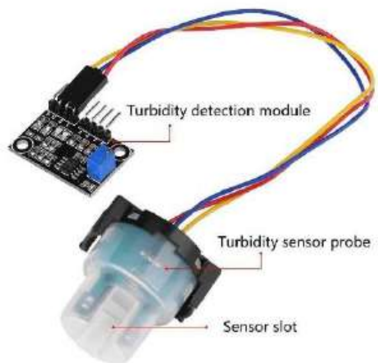

Figure 3.19: Turbidity Sensor

Schematic Diagram:

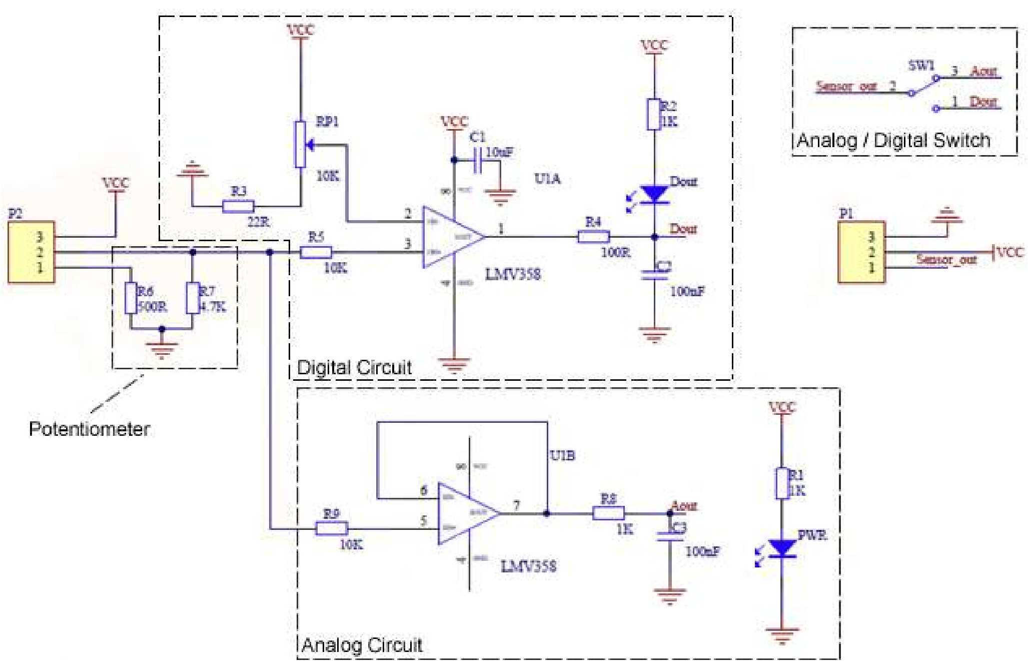

Figure 3.20: Turbidity Sensor Circuit

3.2.7 Buzzer:

The buzzer in the solar lake pool cleaner drone is used to provide an audible alarm when the pH and turbidity sensors detect that the water is dirty. When the pH sensor indicates that the pH level is outside the desired range or the turbidity sensor detects high levels of suspended particles, the drone's microcontroller triggers the buzzer. The buzzer emits a sound or tone to alert the user or maintenance personnel that the water is dirty and requires attention. This helps ensure timely intervention and cleaning actions to maintain water quality and the effectiveness of the pool cleaner drone. Figure 3.16 shows the buzzer used in our project while Figure 3.17 shows its schematic diagram.

Figure 3.21: Buzzer

Schematic Diagram:

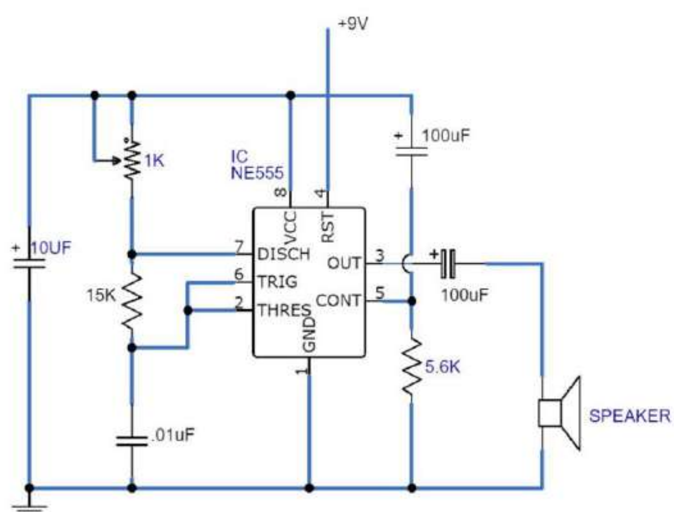

Figure 3.22: Buzzer circuit arrangement

3.2.8 LCD Display:

The LCD display, specifically a 16x2 character LCD, can be used to show the values of a pH sensor and turbidity sensor in a solar lake pool cleaner drone.

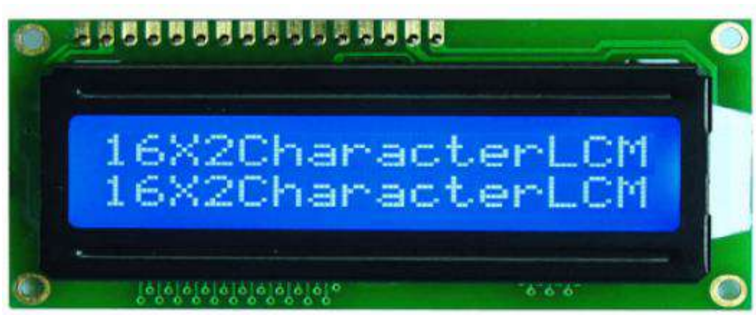

Figure 3.23: 16x2 LCD display Blue LED backlight

Figure 3.18 shows LCD display which will connect the LCD display to the microcontroller or development board used in the drone. The connections typically involve data pins (for sending information), control pins (for signaling commands), and power supply pins. One should use a suitable LCD library or driver for the specific microcontroller. Initialize the library by specifying the necessary settings such as pin configurations and display dimensions (16 columns and 2 rows in this case). Obtain the pH and turbidity readings from their respective sensors. This may involve digital interfaces depending on the specific sensors used. Convert the raw sensor values into meaningful units or values. Send commands and data to the LCD display to update the screen. This typically involves sending commands to position the cursor and writing the sensor values to specific locations on the display. The library functions will handle the low-level details of sending data to the LCD. Repeat the sensor reading and display update process in a loop to continuously monitor the sensor values and update the display in real-time. This allows the LCD to show the latest pH and turbidity readings as they change.

Overall, the LCD display acts as a visual output device, receiving sensor readings from the microcontroller and displaying them in a readable format on the screen.

3.3 Interfacing:

Programming part is the final stage in completing the project where the programming is the mind of the drone that makes decision when controlled by the user. The programming is built by user to make sure the drone follow all the instructions and all sensors able to use when the programming insert to atmega microcontroller328p through Arduino UNO. Without programming, the drone will not be able to move and all sensors will not function because the data send by the sensor will not be able to process and execute.

3.3.1 Arduino Programming:

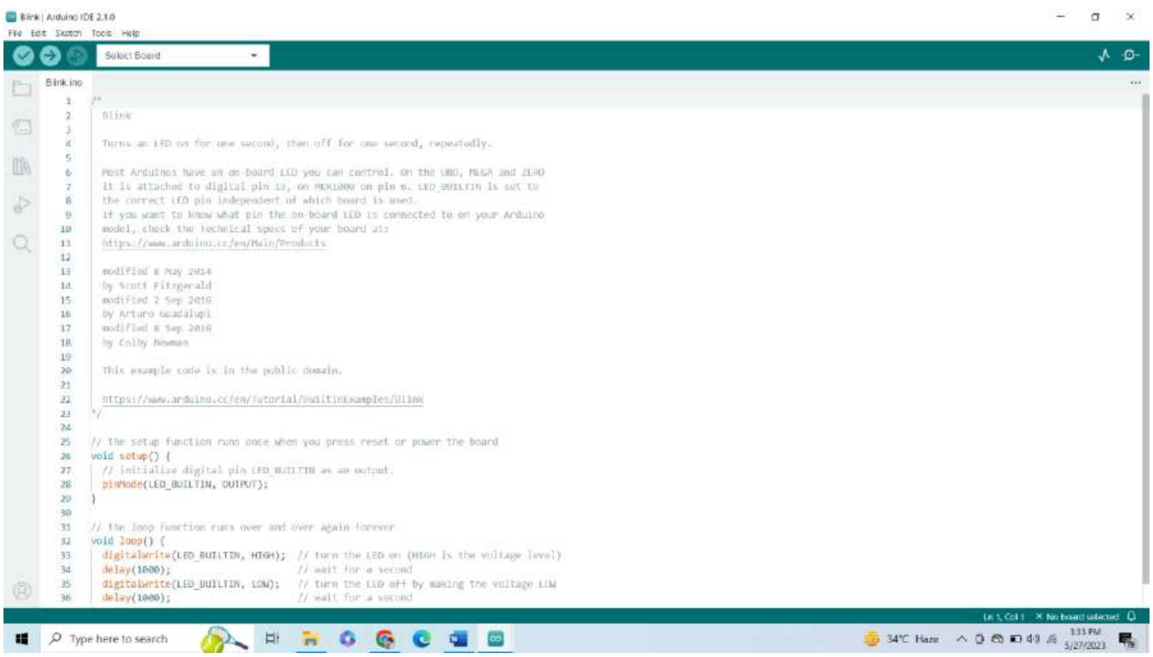

Figure 3.24: Arduino IDE Front Window

Figure 3.19 shows the main window of Arduino IDE programming. This software supports all Arduino's or Atmega microcontroller from all version and in this software, the program will be easy written in C or C++ language. This software is easy to use than others because the programming language is direct and the user did not need to set configuration and to include the library for Arduino because it is built in.

3.4 Assembly of Mechanical Design & Electronics:

The adequate integration of mechanical part, electronic part and programming part is the most important step in the overall design of a solar lake/pool cleaner drone. Mechanical part represents the main physical/body parts that gives the required strength and position of the important parts of the solar lake/pool cleaner drone. If the mechanical parts of the solar lake/pool cleaner drone are not fitted as per requirements, the drone will fail and cannot achieve the target. For example, if the quadrotors unmanned aerial vehicle (UAV) is needed to design for lake/pool cleaning, there will used simple DC motors instead of underwater thruster motors.

Selection/development of electronic parts is second stage in designing the solar lake/pool cleaner drone. After the mechanical parts of the drone are decided, the electronic of the drone will be built/mounted on the mechanical parts. As the objective of the project is to build solar lake/pool cleaner drone to check the acidic and basic nature as well as particles in the water so for that we need separate Arduino UNO, pH and turbidity sensors. For visually observation of the data we need an LCD screen as well. It has also the feature of alarm system. If the pH and turbidity level is hazardous to the humans in pools; the buzzer is installed which will be used as an alarm that the water quality is not good for the humans.

Last part of the design is the programming part where this part is to program the Arduino UNO and Bluetooth module to control the motion of the drone through controller. This part is done by programming the Arduino UNO by using suitable software. The programming part is important for the drone to follow the desired application needs. If the programming is done wrongly, it will produce the wrong output and the drone will not be able to follow the commands given through controller. In conclusion all the parts must be connected in a proper arrangement to each other; if one part fails it will cause the failure of the complete drone.

The final manufactured configuration of the drone is shown below:

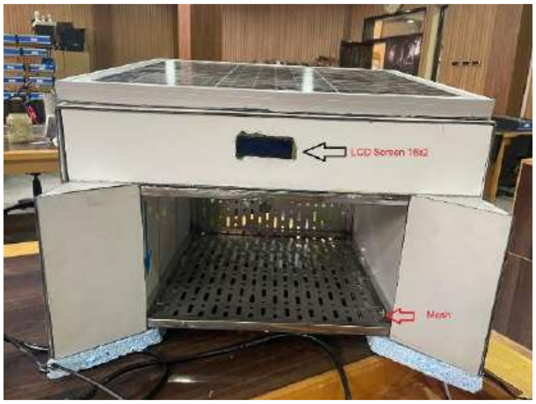

Figure 3.25: Front View

Figure 3.26: Top View

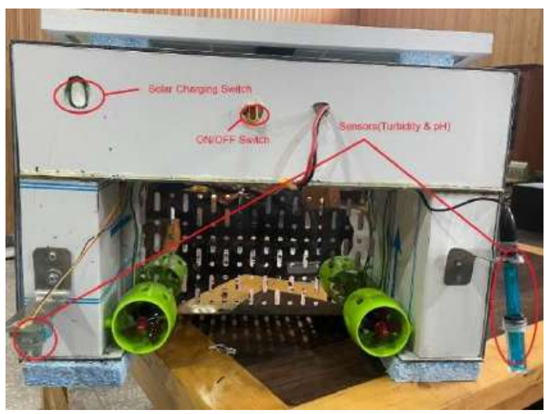

Figure 3.27: Back View

4. RESULTS AND DISCUSSION

This chapter discusses the result of the whole project. The results are based on objective of the project; the drone that is able to collect solid wastes from the surface of pool and lakes as well as check the level of pollution of water through sensors. In this part the result will be discussed in detail to show that the drone has achieved the objectives successfully.

4.1 Collection of Debris:

The result of the collection of debris in the solar lake pool cleaner drone demonstrates its effectiveness in removing various types of debris from the pool or lake. During the testing phase, the drone successfully collected and removed debris such as leaves, twigs, small branches, and other floating particles. The cleaning mechanism, which includes mesh, efficiently captured the debris. The data collected during the testing sessions revealed a high cleaning efficiency of the drone. It consistently removed a significant amount of debris from the surface of the water, resulting in a cleaner and more visually appealing pool or lake. The coverage area of the drone's cleaning operation was extensive, effectively targeting debris across a wide surface area.

The drone's cleaning performance was also assessed based on the time required to complete the cleaning task. The results indicated that the drone operated efficiently, completing the cleaning process within a reasonable timeframe. The ability to navigate remotely the pool or lake allowed the drone to clean the entire surface area effectively, saving both time and effort compared to manual cleaning methods. Furthermore, the drone's cleaning mechanism and design were carefully optimized to prevent clogging or obstruction caused by larger debris. This ensured smooth operation throughout the cleaning process, minimizing the need for manual intervention or maintenance.

Overall, the data collected and analyzed demonstrate that the solar lake pool cleaner drone is highly effective in collecting and removing debris from the pool or lake. Its efficient cleaning performance, wide coverage area, and ability to handle different types of debris make it a valuable and convenient tool for maintaining the cleanliness and aesthetic appeal of aquatic environments.

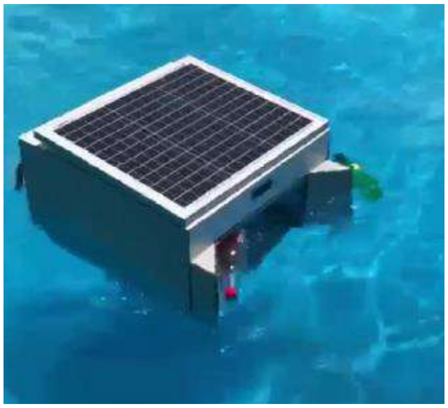

Figure 4.1: Drone colleting debris

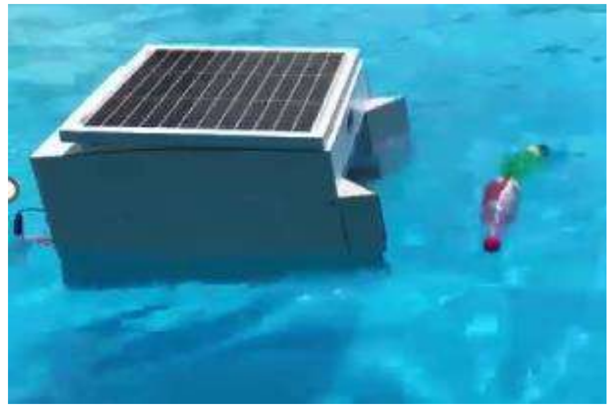

Figure 4.2: Drone while surveying

4.2 Monitoring pollution level:

The result of checking the level of pollution in the water using pH and turbidity sensors, along with the display and alarm system, showcases the effectiveness of the solar lake pool cleaner drone in monitoring and responding to water pollution. The pH sensor accurately measures the acidity or alkalinity of the water, providing valuable insights into its quality. The turbidity sensor measures the level of cloudiness or particulate matter present in the water, indicating the degree of water pollution.

During the testing phase, the sensors successfully detected changes in pH levels and turbidity, enabling the drone to assess the pollution status of the water. The data collected from the sensors was processed and displayed on the 16x2 LED display, providing real-time information to the operator or user. When the water pollution level exceeded a predefined threshold, indicating a high level of contamination, the alarm system in the form of a buzzer was triggered. The loud and distinct sound of the buzzer served as an effective warning signal, alerting users to the presence of polluted water. The combined use of the pH and turbidity sensors, LED display, and buzzer alarm system demonstrated the drone's capability to monitor water quality in real-time and promptly notify users of potential pollution. By providing these essential monitoring and warning features, the solar lake pool cleaner drone contributes to maintaining the cleanliness and safety of the water body, offering an effective solution for pollution management in aquatic environments.

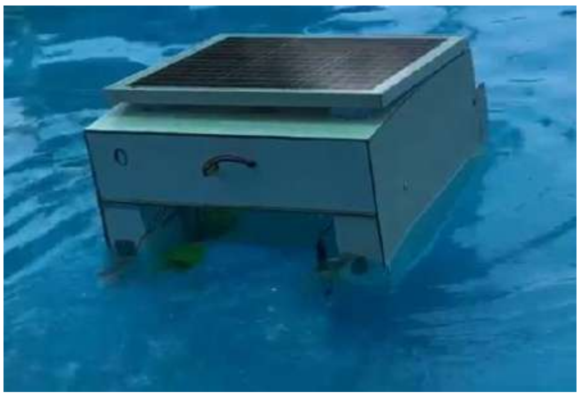

Figure 4.3: Sensors monitoring water quality

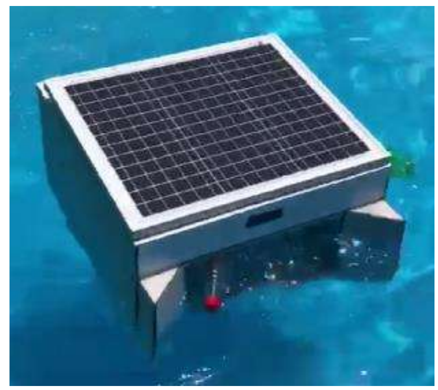

Figure 4.4: LCD display showing pH level

4.3 Discussion:

The solar lake pool cleaner drone discussed in this study represents an innovative and technologically advanced solution for maintaining the cleanliness of pools or lakes. By combining various features such as the ability to clean debris from the water surface, remote control via a mobile device, and monitoring the pollution level through pH and turbidity sensors, the drone offers a comprehensive and efficient cleaning system.

One of the key features of the drone is its ability to effectively clean debris from the surface of the water. With its Unmanned Surface Vehicle (USV) capabilities, the drone can navigate the water surface through mobile control and collect various types of debris, including leaves, twigs, and other floating particles. This feature eliminates the need for manual cleaning or the use of traditional pool cleaning methods, saving time and effort. The integration of mobile control via a mobile device adds convenience and flexibility to the drone's operation. By using a dedicated mobile application users can easily control the drone's movement and cleaning operations. This allows for real-time adjustments and precise navigation, ensuring that the drone covers the entire surface area efficiently. The mobile control capability also enables users to remotely operate the drone from a distance, enhancing usability and user experience.

Additionally, the inclusion of pH and turbidity sensors in the drone enables the monitoring of water pollution levels. The pH sensor provides information about the acidity or alkalinity of the water, while the turbidity sensor measures the presence of suspended particles or pollutants. This allows for real-time assessment of water quality and pollution levels, helping users identify potential issues and take appropriate actions to address them.

Moreover, the drone incorporates a solar panel for charging its battery. This feature harnesses solar energy to power the drone, reducing reliance on external power sources and enhancing its sustainability. The solar panel continuously charges the drone's battery, ensuring longer operation times and minimizing interruptions for recharging.

4.4 Compliance W.R.T Sustainable Development Goals:

The Sustainable Development Goals (SDGs), also known as the Global Goals, are a set of 17 interconnected goals adopted by the United Nations (UN) member states in 2015 as shown in figure 4.5. The SDGs provide a comprehensive framework for addressing the world's most pressing social, economic, and environmental challenges, with the aim of achieving a more sustainable and equitable future for all.

Figure 4.5: Seventeen Sustainable Development Goals

From figure 4.5 our project has targeted following sustainable development goals:

1. Affordable and Clean Energy (SDG 7): The drone's use of solar power aligns with SDG 7, By harnessing solar energy, the drone reduces dependence on non-renewable energy sources and contributes to a cleaner and more sustainable energy future.

2. Sustainable Cities and Communities (SDG 11): The drone's ability to efficiently clean swimming pools supports SDG 11, which focuses on making cities and human settlements inclusive, safe, resilient, and sustainable.

3. Responsible Consumption and Production (SDG 12): The drone encourages responsible consumption and production patterns by reducing the use of chemical cleaners and minimizing energy consumption in pool maintenance. It helps to minimize waste generation and promotes sustainable practices in the upkeep of swimming pools.

4. Climate Action (SDG 13): The solar-powered nature of the drone aligns with SDG 13, which seeks urgent action to combat climate change and its impacts. By utilizing renewable energy and reducing carbon emissions associated with pool maintenance, the drone helps mitigate the environmental impact and contributes to climate change mitigation efforts.

5. Life Below Water (SDG 14): The drone's cleaning capabilities support SDG 14, which aims to conserve and sustainably use the oceans, seas, and marine resources. By efficiently removing debris and contaminants from pools, the drone can help prevent pollution and maintain the cleanliness of water bodies, positively impacting aquatic ecosystems.

6. Partnerships for the Goals (SDG 17): Developing and implementing innovative technologies like the Solar Lake Pool Cleaner Drone requires collaborations and partnerships between various stakeholders, including manufacturers, researchers, and pool owners. By fostering partnerships, the drone contributes to SDG 17, which promotes collaboration for the achievement of all the SDGs.

5. CONCLUSION AND FUTURE WORK

5.1 Conclusion:

The development and implementation of solar lake pool cleaner drones with unmanned surface vehicle (USV) capabilities have successfully achieved the objectives of efficient water cleaning, sensor-based pollution monitoring, and mobile control of water thruster motors.

By utilizing solar energy, these drones operate sustainably, reducing the reliance on conventional power sources and contributing to environmental conservation. Their ability to clean debris from the surface of water ensures a visually appealing and hygienic pool environment. The drones' cleaning mechanisms, coupled with their autonomous operation, offer efficient and thorough cleaning, saving time and resources for pool owners and maintenance companies.

The integration of sensors, such as pH and turbidity sensors, allows for real-time monitoring of water quality and pollution levels. This feature provides valuable insights into the health of the pool ecosystem, enabling proactive measures to maintain optimal water conditions and ensure the safety and comfort of swimmers.

Furthermore, the mobile control capability of water thruster motors adds an element of convenience and flexibility. Through a mobile control interface, pool owners or maintenance personnel can remotely adjust the movement and positioning of the drones within the pool. This feature enables precise cleaning and targeted pollution monitoring, enhancing the overall efficiency and effectiveness of pool maintenance operations.

The successful achievement of these objectives has transformed the pool cleaning industry by offering a comprehensive and innovative solution. Solar lake pool cleaner drones with USV capabilities provide not only efficient cleaning and pollution monitoring but also contribute to sustainable practices and customer satisfaction.

In conclusion, the development of solar lake pool cleaner drones with USV capabilities has successfully achieved the objectives of efficient water cleaning, sensor-based pollution monitoring, and mobile control. By combining these features, this innovative solution brings convenience, sustainability, and improved water quality to pool owners and maintenance companies. The continued advancement and adoption of this technology will contribute to a cleaner, healthier, and more enjoyable pool experience.

5.2 Future Work:

Future work for solar lake pool cleaner drone USVs can focus on several areas to further enhance their capabilities and impact in the pool cleaning industry.

5.2.1 Advanced Sensor Integration:

Expanding the range of sensors integrated into the drone can provide a more comprehensive understanding of water quality parameters. This could include the integration of sensors for temperature, dissolved oxygen, chlorine levels, or other relevant parameters. By collecting and analyzing a wider range of data, the drones can offer more detailed insights into pool water health and enable more targeted maintenance actions.[4]

5.2.2 Enhanced Autonomous Navigation:

Improving the autonomous navigation capabilities of the drones can enhance their ability to maneuver efficiently and effectively within the pool environment. This could involve advanced obstacle avoidance algorithms, improved mapping and localization systems, or the incorporation of machine learning techniques for adaptive navigation based on previous cleaning patterns and pool configurations.[4]

5.2.3 Integration of Water Treatment Systems:

Integrating water treatment systems into the drones could offer a comprehensive solution for pool maintenance. These systems could include features such as water filtration, UV sterilization, or chemical dosing capabilities. By combining cleaning and treatment functionalities, the drones can actively contribute to maintaining optimal water quality while reducing the need for separate equipment and manual interventions [4].

5.2.4 Integration with Smart Home Systems:

Integrating the drones with smart home systems or pool management platforms can offer seamless control and monitoring capabilities for pool owners and maintenance companies. This could include features such as scheduling, and real-time notifications for pool maintenance tasks, water quality alerts, or operational status updates. The integration with existing smart home ecosystems can provide a more holistic and convenient pool maintenance experience [4].

By focusing on these areas of future work, the solar lake pool cleaner drone USVs can continue to advance, offering improved cleaning capabilities, intelligent operation, and enhanced data-driven decision-making. These advancements will not only streamline pool maintenance operations but also contribute to sustainability, cost-effectiveness, and overall customer satisfaction in the pool cleaning industry.

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APPENDIXES

The source codes are given below.

PROGRAMMING OF CENTRAL CONTROLLER:

```
#include <Servo.h>
Servo esc1;
Servo esc2;

char BluetoothData;

void setup() {

  Serial.begin(9600);
  esc1.attach(9);
  esc2.attach(10);
  //Set Digital Pins 4 to 7 as Output
 esc1.write(1000);
    esc2.write(1000);
}

void loop() {

  if (Serial.available()){

    BluetoothData=Serial.read();

    if(BluetoothData=='R'){
  for (int a = 1000 ; a <=1950; a += 10) {
    esc1.write(a);
    esc2.write(a);
    delay(5);
  }
    }

    if(BluetoothData=='G'){
  for (int c = 1000 ; c <=1950; c += 10) {
    esc1.write(1000);
    esc2.write(c);
    delay(5);
  }
    }
    if(BluetoothData=='B'){
  for (int b = 1000 ; b <=1950; b += 10) {
    esc1.write(b);
    esc2.write(1000);
    delay(5);
  }
    }
   if(BluetoothData=='r'||BluetoothData=='g' ||BluetoothData=='b'){
 esc1.write(1000);
    esc2.write(1000);
    }

  }

  delay(10);

}
```

PROGRAMMING FOR PH SENSOR:

```
float calibration_value = 21.34 - 0.7;
int phval = A0;
unsigned long int avgval;
int buffer_arr[10],temp;

float ph_act;

void setup()
{
pinMode(A0,INPUT);
 Serial.begin(9600);

//timer.setInterval(500L, display_pHValue);
}
void loop() {
 // timer.run(); // Initiates SimpleTimer
 for(int i=0;i<10;i++)
 {
 buffer_arr[i]=analogRead(A0);
 delay(30);
 }
 for(int i=0;i<9;i++)
 {
 for(int j=i+1;j<10;j++)
 {
 if(buffer_arr[i]>buffer_arr[j])
 {
 temp=buffer_arr[i];
 buffer_arr[i]=buffer_arr[j];
 buffer_arr[j]=temp;
 }
 }
 }
 avgval=0;
 for(int i=2;i<8;i++)
 avgval+=buffer_arr[i];
 float volt=(float)avgval*5.0/1024/6;
  ph_act = -5.70 * volt + calibration_value;
//ph_act=ph_act+15;
 Serial.println("pH Val: ");
 Serial.print(ph_act);
 delay(1000);
}
```