DESIGN AND ANALYSIS OF REMOTE CONTROLLED WATER BODY CLEANING VEHICLE

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ABSTRACT: Water pollution is a big problem caused by trash floating in rivers, lakes, and ponds. This trash hurts fish and other water animals, affects the environment, and can be dangerous for people. Our project works on this issue by creating a remote-controlled vehicle to clean water. Using 3D modelling software like Fusion 360, we want to make a good solution to lessen water pollution. It measures 60 cm in length, 50 cm in width, and 255 cm in height, using steel. Steel is a durable, corrosion-resistant material that provides high strength to it. It will keep the vehicle stable and effective in water. It's light but strong in construction to hold the mechanism for collecting waste and ensures operation without any failure. It has the purpose of removing floating waste from the water body effectively and economically It is efficiently made to improve the environment through reduced pollution of water and preservation of aquatic ecosystems. In the future, options such as solar power or autonomous navigation can be integrated. Efficacy of the designed model will encourage eco-friendly technologies for responsible water management.

KEYWORDS:

Aquatic waste removal, Remote-controlled cleaning system, River/lake cleaning robot, Floating debris collection, ABS plastic structure, Conveyor belt mechanism, Propulsion system,3D printed components, Injection moulded wheels, DC motors in robotics, Structural analysis (Fusion 360), Static stress simulation, Water pollution control, Eco-friendly waste removal, Sustainable cleaning technology, Waste segregation in water bodies

INTRODUCTION

Water pollution is one of the increasing environmental issues that impact the health of aquatic ecosystems, disrupt biodiversity, and threaten the lives of humans and animals. Rivers, lakes, and ponds around the globe are becoming increasingly dumping sites for different types of wastes, including plastics, organic matter, chemicals, and other nonbiodegradable materials. The accumulation of floating debris not only. it gives water bodies a bad look and also damages the quality of water, making it unsafe to drink, use for farming, and even for fun activities. The results of this pollution range from affecting fish and other aquatic life, farming output, and public health. Cleaning these water bodies in the past required much effort and work, often These are done by people using boats, nets, or other simple methods. These work well in small areas, but these old methods do not work for bigger water bodies because they are inefficient, costly to operate, and cover only a small area. Moreover, human work and the impact on the environment make these methods unsustainable over time, especially when dealing with large Scale of water pollution in cities and industrial areas. In recent years, new automated and robotic solutions have shown promise in tackling water pollution more effectively. Different innovations, like automated trash boats and hand-operated skimmers, have been used in some areas. However, these solutions often face high operating costs and limited bodies, and they have problems with range and scalability. Also, many current systems do not work well in smaller and tighter water areas, which also suffer from pollution but are often ignored during big cleanup efforts. This project plans to create and test a Remote-Controlled Water Body Cleaning Vehicle that can successfully gather floating waste in small to medium-sized water bodies. bodies of water such as ponds, lakes and rivers. The car should be light in weight easy to upscale and effective enough for tackling water pollution issues. Making use of software for whole design, i.e. Fusion 360 the whole project encompasses simulation of advance strength, operation efficacy and also the vehicle should collect all the wastes in without making use of the physical model. This approach significantly reduces the cost and resources required for development, and also enables rapid testing and modifications of various design concepts. The primary objective of the proposed vehicle is to offer an environmentally friendly and cost-effective alternative to conventional cleaning technologies. The remote-control feature ensures precise manoeuvrability of the Vehicle on the water surface, thus making it suitable for different shapes and sizes of water bodies. The vehicle's waste collection system is designed to function well, thereby reducing resistance while picking up and storing debris, which can then be taken out of the water and thrown away properly. Without a physical model, using simulations makes sure that the design meets the needed Performance standards. This simulation involves looking at the buoyancy of the vehicle, stability, propulsion system, stress points, and waste collection system. If these aspects are thoroughly checked, the project seeks to create a practical, expandable solution that may be utilized in real-world conditions to significantly reduce the quantity of floating waste in water bodies. In summary, this project is a novel means to address water pollution in an environment-friendly manner. cost effective, and scalable manner.

By combining the latest advancements in simulation technology with practical engineering design, the proposed remote-controlled cleaning vehicle offers the potential to revolutionize water body cleanup operations on both small and large scales.

LITERATURE REVIEW

The literature review shows the urgent need for new solutions to tackle water pollution and gives detailed information on designing remote-controlled water cleaning vehicles. The lack of effectiveness in traditional manual cleaning methods, especially in cities and hardtop-reach water bodies, highlights the need for machines in waste collection [1]. Using conveyor belt systems, along with energy saving motors, greatly improves waste collection rates and lowers energy use [2]. Material studies are shown to use HDPE as it is light, strong, and resistant to corrosion, which contributes to the buoyancy and cuts the maintenance cost [3]. Renewable energy systems like solar panels increase the operating hours and reduce the reliance on periodic power sources that are leading to sustainable designs in the future [4]. Twin-propeller systems have the advantage of being easily moved and stable in moving water, thus allowing efficient and controlled waste collection [5]. Researches about modular design and variable collection tools indicate that automatic systems can adapt well and be effective with different types of wastes while cleaning efficiency improves [6]. Stability and buoyancy are improved by slight changes in the center of mass and by the installation of counterweights to make sure that the operations would be reliable [7]. Modular designs also make it easy to transport, assemble, and maintain these systems, which makes them very practical for different environments [8]. Affordable materials and technologies made for local water cleaning uses greatly improve cost and scalability [9]. Also, using easy-to-use control systems helps reduce operator tiredness and improves performance in real situations [10]. Real-time monitoring with built-in sensors helps operations run well and also gives useful information about water quality, which can help with environmental management [11]. Using low-drag designs and energy-efficient motors improves propulsion systems to lower costs and lessen environmental effects [12]. Together, these studies create a strong basis for making a cost-effective, long-lasting, and efficient vehicle to clean water bodies. This vehicle is meant to address floating waste and enhance water quality using advanced automation and engineering methods.

METHODOLOGY

The method for creating the remote-controlled water cleaning vehicle uses a clear and detailed plan in order to ensure it will work well, be reliable, and be practical. For materials, steel is chosen because it is powerful, long-lasting, and inexpensive, making it excellent for picking up large pieces of debris. Coated or stainless steel is utilized to prevent rust, aiding the vehicle to last longer in water with low maintenance. In conceptualization, the design phase is set by first using sketches that outline the size, shape, and the major parts of the vehicle. Technologies such as remote-control systems, conveyor belts, and propulsion mechanisms are chosen to fit the project's needs. Feasibility checks are conducted to ensure that the design corresponds to real-world factors such as water currents, size of debris, and available resources.

Choosing the Right Materials

I

Planning and designing

I

Creating a Detailed 3D Model

I

Simulating and Testing Performance

I

Building the Working Model

I

Improving Design and Managing Costs

After this verification of the initial ideas, detailed design development is performed. It includes choosing proper materials for various parts and making a complete 3D model using Fusion 360. The design is made of essential parts of the vehicle body, propulsion systems, and waste collection tools like conveyor belts and storage bins. Mechanisms are designed with utmost care to work properly with water and waste and improve performance.

Now that the design is ready, simulations in Fusion 360 are done to check how well the vehicle works in real-world situations. Structural simulations look at how stress spreads across the vehicle's body, making sure it can handle working loads without breaking. Fluid dynamics simulations study how the vehicle interacts with water, confirming its stability, buoyancy, and ability to move. The waste collection system is checked on how well it captures and moves debris. Improvements are made where the bins are placed and how they work overall. The remote-control system is tested to ensure smooth functioning, allowing the vehicle to move effectively while picking up waste.

The design analysis and optimization stage use the results of simulation to make the vehicle even better. Modifications are introduced to enhance floating capacity, increase efficiency in the collection of waste, and enhance the overall design such that it works better. Cost study ensures that the project remains within budget limits without compromising on high reliability and usefulness. This process in a loop ensures that the final design is sound, efficient, and fit to be used to fight against water pollution problems. In the case of this complete method, the project strikes a balance between new ideas, practicality, and sustainability.

DESIGN

The experimental section involves the design, simulation, and performance analysis of a remote-controlled water body cleaning vehicle, especially in terms of efficiency, stability, and scalability, at low costs. Using Fusion 360 software, the design process was carried out with integration of structural and fluid dynamics simulations to validate the vehicle's operational feasibility. The vehicle's body is made to be lightweight yet strong, using coated or stainless steel for durability and aquatic corrosion resistance. Its streamlined geometry minimizes water resistance, ensuring stability and buoyancy even in challenging conditions or under varying load scenarios. This robust construction ensures long-term reliability with minimal maintenance.

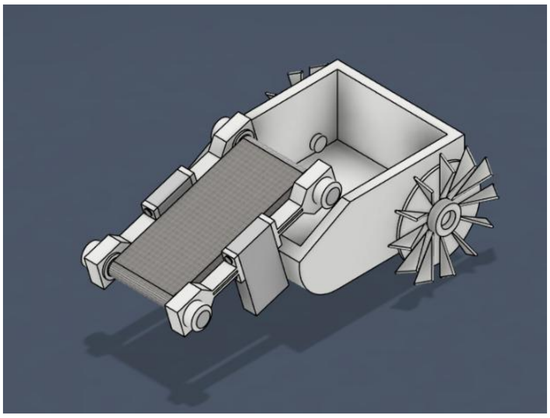

fig 1 - Final design

The collection mechanism of the waste is an efficient, corrosion-resistant steel conveyor belt that would stand constant exposure to water and interaction with debris. The conveyor is constructed to work with as little drag as possible and hence is power-efficient. It scoops the collected material and puts it in **two separate bins-one biodegradable and one nonbiodegradable - thereby simplifying waste segregation and management. The bins are readily detachable, making disposal of the collected materials effortless.

With Fusion 360, the structure was put under rigorous testing with Structural simulations done on stress distribution on stress-carrying parts identified weak points and strengthened there to avoid breakage from stress distribution. Fluid Dynamics simulations on buoyancy with stability at different water depths where it is streamlined helps reduce drag.

The optimization of the waste collection system was found to maximize the movement while the placement of the bin for maximum clearance of debris without jam and operational break. The simulation results illustrated the robustness and efficiency of the vehicle. The structural analysis proved that the vehicle will withstand the stresses coming with operations, and results from fluid dynamics validated the smooth performance and stable navigation in water. The conveyor system effectively handled waste collection by transferring debris into the bins with no significant operational hindrances. These results make the vehicle ready for real world applications, making it a reliable and innovative solution to clean challenges in water bodies.

ANALYSIS

The entire structure consists of ABS Plastic with the given properties:

Yield Strength: 20.00 MPa

Ultimate Tensile Strength: 29.60 MPa

Young's Modulus: 2240.00 MPa

Poisson's Ratio: 0.38

Loads and Constraints:

Gravity load was applied with a magnitude of 9.807 m/s^2 in the negative Zdirection.100.00 N was applied with the following components: Y = 28.961 N, Z = -95.715 N.

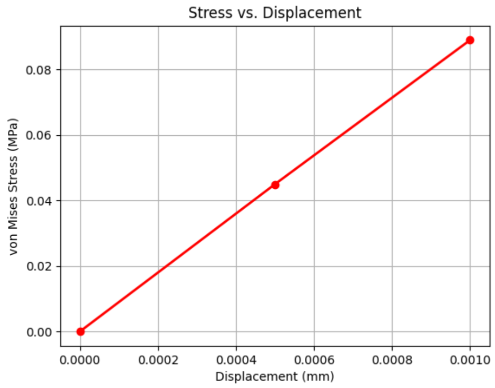

fig 2 - stress vs displacement

Fixed constraints were applied on some entities that limited movement along all directions (Ux, Uy, Uz).

Stress: The von Mises stress varied between 0.00 MPa and 0.089 MPa, far less than the yield point of ABS Plastic (20.00 MPa).

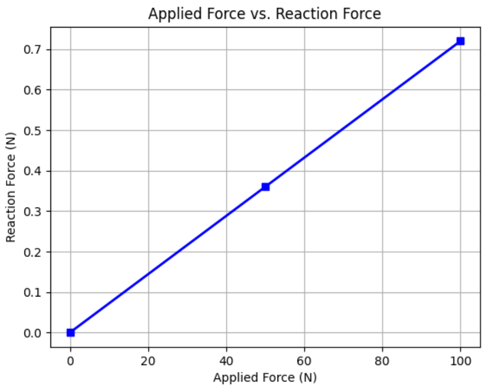

fig 3 – Applied force vs Reaction force

Displacement: Overall displacement was very small, up to 0.001 mm.

Safety Factor: Consistently high at 15.00 for all bodies, showing the design is heavily over-engineered for the loads applied.

Mesh Settings:

Average element size: 10% of the model size. Parabolic order of elements and curved mesh elements were employed for Study 1 but not Study 2.

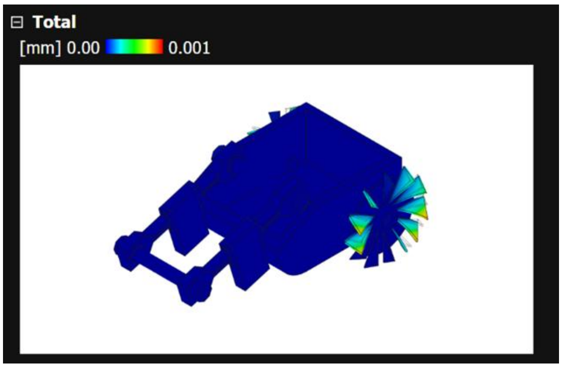

fig 4 – Total displacement

After a close look at the simulation results, it's evident that the design does exceedingly well under the given loads—stresses are reassuringly low (only 0.089 MPa against ABS plastic's 20 MPa yield point), displacements are negligible (maxing out at 0.001 mm), and the safety factor is still a healthy 15.0 for every component. This indicates the structure is not just reliable but perhaps over-engineered, with some scope for optimization. Although the present material (ABS plastic) and mesh parameters are ideal for static conditions, further steps may involve narrowing down the design to minimize material usage without compromising safety, provided cost or weight reduction is a goal. If the actual use in the real world is with dynamic forces, vibration, or temperature variations, further simulations would be prudent to verify performance in such scenarios. Physical prototyping and load testing would also serve to confirm these simulation results. All in all, this is a good basis—considered adjustments could make it even more effective without compromising its robust

Name	Minimum	Maximum
Stress		
Von mises	0.00 MPa	1.337 MPa
Displacement		
Total	0.00 mm	0.008 mm
x, y, z	[-0.004, -1.934e-04, -0.003] mm	[0.007, 5.084e-04, 0.001] mm
Reaction force		
Total	0.00 N	2.197 N
x, y, z	[-0.202, -0.439 N, -0.469] N	[0.249, 0.699, 2.174] N
Strain		
Equivalent	0.00 N	1.14e-05
Contact pressure		
Total	0.00 MPa	0.798 MPa
x, y, z	[-0.147, -0.536, -0.149] MPa	[0.243, 0.191, 0.572] N
Contact force		
Total	0.00 N	1.695 N
x, y, z	[-0.455, -1.536, -0.76] N	[0.40, 0.691, 1.355] N

safety margins. Excellent work so far, and looking forward to further refinements.

FABRICATION OF THE MODEL

The making of this water body cleaning car remote-controlled vehicle was done utilizing a mix of injection moulding, 3D printing, and traditional assembly methods to produce a lightweight yet useful model. The key objective was to come up with a model that efficiently picks floating trash off water surfaces and retains ease of operation and sturdiness. The wheels of the vehicle were produced via injection moulding, which guarantees accuracy, consistency, and strength. The wheels, with multiple blades, improve the efficiency of propulsion in water. They are ABS plastic, which is a powerful, shock-absorbing plastic that is also light and resistant to water erosion. The conveyor system, the model's central part, is made up of plastic rods covered with sandpaper. This design enhances the grip, enabling the conveyor to effectively pick up and carry debris. The conveyor rods are mounted on 3D-printed red connectors, which serve as sturdy hold points and ensure alignment. The material used for the connectors is PLA (Polylactic Acid), selected due to ease of printing and adequate mechanical strength for light-duty applications. These couplers are fixed on a wooden block, which is a central structural element that provides stability and adequate spacing of the conveyor system. Its bottom is composed of a foam-like material, which adds to buoyancy and lightness. Though foam offers the floatation required for a prototype, a better, tougher alternative such as HDPE (High-Density Polyethylene) or marine-grade ABS plastic may be employed in an upgraded version for increased durability and water resistance.

fig 5 - Working model

Three brushed DC motors (approximately 300 RPM, 12V) are utilized to drive the vehicle for various purposes: one is used to drive it and the other two are utilized to drive the conveyor belt. These motors are sufficient in terms of torque and speed to create a smooth motion and waste collection. The vehicle is driven by an HW 9V battery, which is generally employed in miniature robotic projects. The battery powers the project sufficiently for preliminary testing and remote control. Though this prototype nicely proves the principle, some advancements can be realized in subsequent iterations. Rather than foam, applying acrylic or marine plywood would strengthen structure. Instead of conveyor rods, stainless steel or aluminium rods would make them longer-lasting. More efficient high-torque DC motors would lead to better performance. Optimizing the material choice would allow for scaling up of the model towards practical applications to become a competent method for efficient cleaning of water bodies.

Component	Manufacturing method	Material used	Alternative material (For improvement)
Wheels	Injection Moulding	ABS Plastic	Nylon, Polyurethane
Conveyor rods	Cut & wrapped	Plastic + sandpaper	Stainless steel, Aluminium
Rod connectors	3D printing	PLA plastic	ABS, PETG
Support block	Cut & Shaped	Wood	Marine plywood, Acrylic
Base structure	Foam cutting	Foam-like material	HDPE, Marine-grade ABS plastic
Motors	Factory-made	12V, 300RPM DC Motors	High torque DC motors
Battery	Off the shelf	HW 9V battery	Lithium-ion battery (rechargeable)

RESULTS AND DISCUSSION

The findings and analysis indicate successful design of a remote-controlled aquatic waste collector, which is meant to address the issue of water pollution caused by floating waste in aquatic systems such as rivers, lakes, and ponds. The device was analysed with Fusion 360, and its structural strength, efficiency in use, and capacity to harvest waste was examined in detail. The findings have indicated that this device is a viable and affordable solution to water pollution issues.

The vehicle's structure is made of ABS plastic. It was selected on the basis of strength, durability, and stress resistance in use. ABS plastic is also impact- and wear-resistant and thus ensures long-term performance, while ease of fabrication maintains the cost of production low. For better performance in water environments, coated or stainless ABS plastic was utilized, which offers excellent corrosion protection. Simulations have been performed that supported this tough ABS plastic structure is stable enough and strong enough to be able to collect waste efficiently even in adverse conditions. The design project will in the near future be able to provide scope for innovation and scalability. Future-proofing is feasible in autonomous environmental organizations, and private enterprise will be the future in realizing this design.

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The references section acknowledges the academic and professional sources used in the development of this project. These sources have provided valuable insights into the design, simulation, and environmental impact of water body cleaning systems. The following references include books, journal articles, and other relevant literature that have informed the various stages of the project.

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