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DESIGN AND MANUFACTURING OF SEMI-AUTOMATIC ROBOT FOR CLEANING OF WATER-BODIES

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Abstract: ***Water is a basic need for all living beings, the increase in water pollution in the form to waste debris is hampering the life of the aquatic animal and has a huge impact on the environment. This project emphasis on design and manufacturing of Semi-automatic robot for cleaning of floating waste on the surface of water bodies. The work has been done looking at the current situation of our national lakes, rivers and ponds which are dump with sewage and loaded with pollutants, toxic materials, debris etc. The government of India has initiated projects to clean rivers and has invested huge capital in many rivers cleaning projects like Namami Gange, Narmada Bachao and many major & medium projects. Considering this, this robot has been designed to clean floating waste on the water surface of lakes & ponds. The conveyor mechanism of the robot collects the waste which floats on water bodies and the collected waste can be easily stored and further disposed of by the robot. The robot cleans wastes found such as plastic wastes, garlands, bottles and other wastes found floating on water. A robot will lift the waste surface debris from the water bodies, this will ultimately result in the reduction of water pollution and lastly, the aquatic animal's death to these problems will be reduced.***

Thus, the project will reduce the risk involved in manual cleaning, increase the productivity of workers, generate an efficient way to control the floating waste on the surface of water bodies and reduce the strain on the environment and marine life.

Keywords- *Semi-Automatic robot , Floating Waste, Namami-Gange, Water, Pollution*

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I INTRODUCTION

Lakes are an important feature of the Earth's landscape and they are extremely highly valuable ecosystems and provide a range of goods and services to humankind. It is a significant source of precious water, provides habitat to plants and animals, moderates the hydrological extreme events (drought and floods), influence climate. It enhances the beauty of the landscape and offers many recreational opportunities. Lakes have a very special significance in India. For the last two decades, as more and more people are migrating to cities the urban civic services are becoming less adequate. As a result, almost all urban water-bodies in India are suffering because of pollution and are used for disposing of untreated local sewage and solid waste, and in many cases, the water bodies have been ultimately turned into landfills. This causes water pollution on a large scale. Contaminants may include organic and inorganic substances. Elevated temperatures can also lead to polluted water. A common cause of water pollution is the use of plastic and other non-degradable substances used by industrial manufacturers, which are dumped into water bodies. While plastics cause a major hazard to seabirds, fish, and other marine creatures. Due to such kind of pollution, there are many harmful effects on humans, aquatic animals as well as on the environment. The decrease in oxygen levels affects the aquatic life and causes a drastic change in food chain composition, reduce species biodiversity, and foster invasion by new thermophilic species. Due to the drinking of contaminated water, various diseases are caused affecting human health.

II LITERATURE REVIEW

1. Zhongli Wang and Yunhui Liu "Design and hydrodynamic modeling of aquatic system" International Conference on Advanced Intelligent Mechatronics, The Chinese University of Hong Kong, China, 2008

This paper models hydrodynamics of the prototype boat using the a model approach based on a simplified model of three degrees of freedom. The hydrodynamic forces and moments of the body, propeller and steering forces are derived. Using the hydrodynamic model, numerical simulations on viscous resistance of the water, the velocity field and pressure field around the boat.

2. E.K. Boulougouris "Efficient Oil Spill Confrontation by Innovative EU-MOP Units"

EU-MOP is the acronym for Elimination Units for Marine Oil Pollution project. The primary target of the project is the design and proof of concept of autonomous EU-MOPs, capable of mitigating and eliminating the threat arising from oil spill incidents. The units will be released in the oil spill area, track the oil concentration specifics of the spill using proper sensors and apply mechanical countermeasures locally. In this paper the design features of the units were presented & the global structure design of the two hull (boat) forms, MonoCat and Catamaran, were carried out using the FEA software.

3. Pranay Agrawal and Bishakh Bhattacharya "Aquatic multi-robot system for lake cleaning"

This paper discusses the design of a multi-robot system of autonomous aquatic vehicles that can be used for cleaning of lakes and maintenance of fisheries. The traditional method of removing the weeds manually and collecting them along with other surface wastes is highly inefficient and labour intensive. Aimed at automating the entire process, the robots make use of tactile sensors and wireless communication to traverse autonomously and collectively perform cleaning operations such as removing the surface impurities, pumping oxygen into the water, spraying chemicals and distributing food at appropriate locations along with measuring the water quality.

Objectives

• To overcome the difficulty of removing waste particulate floating on water surface.

• To reduce the man power, risks and time consumption for cleaning the river.

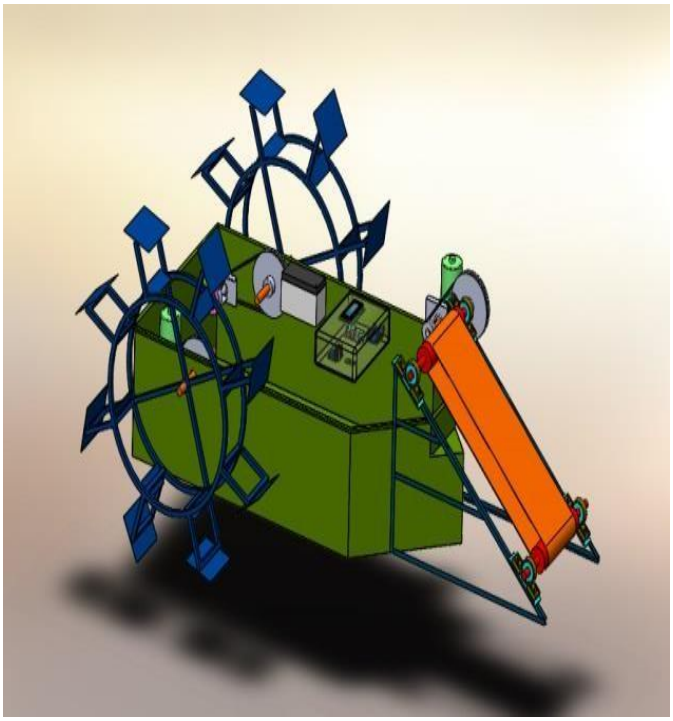
• To make environment friendly machine.

• To make a cost effective, light weight and efficient machine so it can also be used in small water bodies

III WORKING

The robot is designed according to objectives determined during the course of study. All components are mounted on main-frame. The conveying mechanism consist pulley and cleated rubber belt arrangement which help in picking the waste from water surface. The cleated belt ensures no slippage of waste material during the conveying process. This waste is collected in the storage tank of 10 kg capacity mounted at the rear side of the robot. A paddle wheel on each side of robot driven by motor help in propelling the robot while floating. There are three motors in the robot one wiper motor for conveying mechanism and other two motor for paddle wheel. These motors are controlled by operator using remote control connected by Bluetooth module. The electronics unit mounted at rear of robot consists of battery and controlling system like microcontroller, motor driver and Bluetooth module. The robot stays afloat with the help of catamaran type of hull system.

• Main frame– To accommodate various components

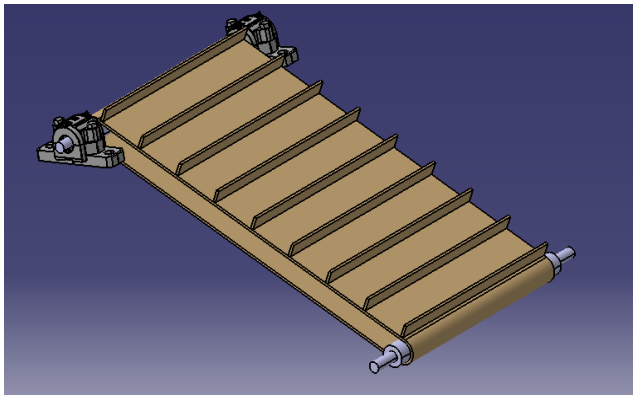


- Storage tank – To collect waste
- Motor – To drive the mechanism
- Shaft – To transmit power from motor to pulley
- Pulleys- To transmit power & motion from shaft to cleated belt
- Cleated belt- To lift and transfer waste to storage tank
- Paddle wheel- To propel & maneuver the robot
- Hulls – To float system

IV DESIGN & CALCULATIONS

1. Design of Conveyor

1.1 Selection of Belt- Belt is selected based on the functional requirement; the belt selected is Side-walled cleated PVC belt.



1.1 Power Calculations

Total power = Power required to lift the load

+ Power required to overcome friction P = Pl + Pf

Pl = ρgQH ; Pf = CoρgQL

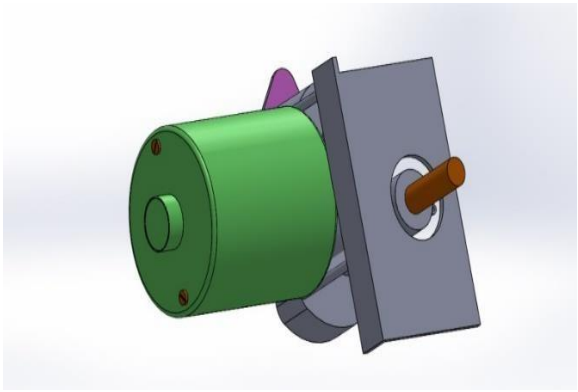
Q= Kb^2v =2.2 * 10^{-4}(0.9*0.4 - 0.05) 2*0.7

= ***0.014 m3/sec***

Pl = 980 * 10 * 0.014 * 0.350 = **48 W**

Pf = 0.018 * 10 * 0.014 * 0.6 = **38 W**

1.2 Selection of motor- Based on power required selected motor is 12V 55rpm Geared motor.



1.3 Belt tension- Considering the belt tension in tight & slack sides, we get

$(T2 – T1) * r * 2\pi N/60 = P$; $T1/T2 = e\mu\Theta$

Solving these 2 equations we get; T1= 100.23 N, T2= 31.72 N

1.5. Shaft Calculations

The shaft is design according to ASME standards. Maximum allowable shear stress (τ) = 0.18 * Sut = 100 Mpa

$T = \sqrt{((Kb * M)^2 + (Kt * T)^2}$

$T=(\tau/J) * R$

Maximum bending moment M= 2700 Nmm

Maximum torque T = 15915 Nmm Diameter calculated= 18.8 mm ≅ 20 mm

1.6. Bearing Selection

P = Xf + Yf; F = 135 N; X=1 Y=0

Expected bearing life- The machine will work 4 hours a day and expected life of robot is 5 years L10h= 7300 hrs,

L10= 7300* 60* 60/ 106 = 23.68 MR

From manufacturers catalogue bearing selected for 20 mm diameter shaft is Pedestral ball bearing.

D0 = 42, C0 = 5000N, W= 12 mm, C= 1360 L10 = C/P 10^3; Cr = 401.36 N

As Cr is less than C selected bearing is safe.

2. Design of Storage tank

2.1 Material selection- Selected material is stainless steel from design data book. Grade of material selected is SS304 Capacity- 10 Kg of waste is required to be collected, hence volumetric capacity V= m/ρ Average estimated density of waste is 200 Kg/m3. Hence V= 0.05 m3

Height of storage tank is 300 mm selected from conveyor height and L/W ratio for displacement hull type is 2:1

Therefore, L = 600 mm, H= 300 mm, W= 300 mm

2.1 Welding calculations-

The manufacturing process selected for storage tank is Tungsten inert gas welding Maximum allowable shear stress is 0.45 times tensile stress

τ = Sf/Sa=0.45* 215/5 = 5400/2*600*t

Hence, thickness of weld t = 0.46 mm

3. Design of Frame-

3.1 Frame calculations- Allowable tensile stress Syt/FOS=70 (FOS=3)

σ = M/I*y.

Maximum bending moment found among all sections of frame is M= 74250 Nmm

For hollow square box pipe of 2mm thickness

70= 135*550*12*(d/2) (D-d) * (D^3-d^3)

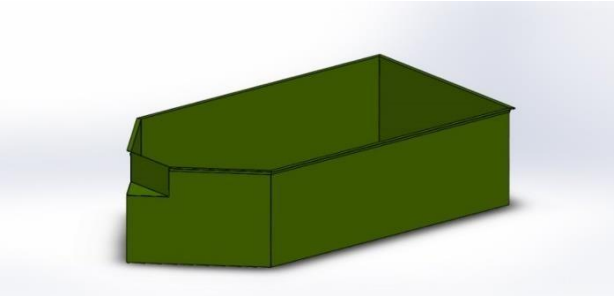
D=19.4 d= 17.4. Hence, square box pipe of 20 *20* 2 mm is selected for frame.

3.2 Weld Calculations- Maximum shear stress is 0.45 times tensile stress

τ max= $\sqrt{(\tau^2 + (\tau n/2)^2)}$ From this the thickness of weld calculated is t =2.15 mm

4. Design of Hull- Estimated weight of body= 10 kg waste + 6.3 storage tank + 16 kg conveyor system + 7.5 kg frame = 40.5 kg 40.5 kg + 20% of 40.5 kg = 48.6 kg (L/W ratio for displacement hull type is 2:1) Depth of immersion= ρ H A= M 1000 * H * 2 *1 * 0.25 + 1000 (H-100) * 0.6 * 0.3 = 45

Thus, H = 92 mm = 0.092 m



5. Design of Water-wheels

5.1 Power calculations- Power required to run robot
Drag force= 0.82 * A * ρ V2 /2 = 10 N Force required to accelerate F= ma=45*2=90 N

Power P = F * V = 100 * 0.7 = 70 W

Hence, 2 motors of 40 W each are required.

5.2 Design of Blade

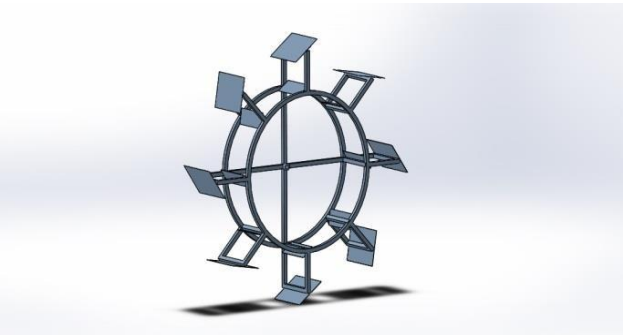
Force generated F = ρ A dv 100 = 1000 * A * ωr

Area A =0.049 m2 \ Calculation of area of blade L = 0.049/2 = 156.5 mm

Thickness of blade plate is σ = M/I*Y

σ = Syt/ FOS= (100*160*t/2)/ (160*t3/12)

Hence thickness of blade is 2.49 mm



5.3 Design of shaft

Maximum allowable shear stress (τ) = 0.18

* Sut = 100 Mpa

T = √((Kb * M)2 +(Kt *T)2

Maximum bending moment M= 8000 Nmm Maximum torque T = 35000 Nmm Diameter calculated= 17.81 mm ≅ 20 mm

6. Stability

The body of the lake cleaning robot be 50 kg approximately.

Force exerted by weight, Fg

Fg = mass x g = 50 × 9.81= 490.75 N

Buoyant force, Fb = volume x Density x g Here, V = Volume = 0.79 cubic meters

Fb = volume x Density x g= 0.79 x 997 x 9.81

= 7726.65 N; Thus 7726.65 > 490.75 Fb >Fg

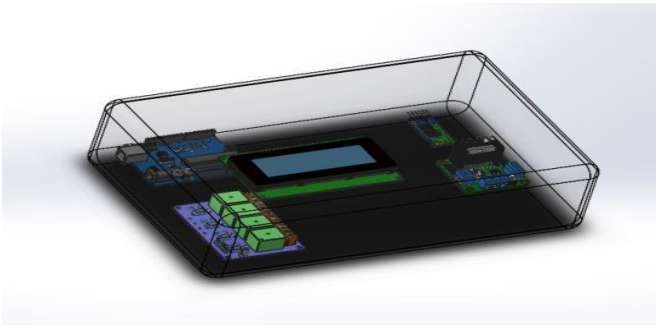
Hence, the robot is stable.

7. Controller

7.1 Arduino Uno – The Arduino uno is the most common and widely used Arduino processor boards.

7.2 Motor Driver- The L298 Driver is a high voltage, high current dual full bridge driver designed to accept standard TTL logic levels and drive inductive loads such relays, solenoids, DC and stepping motors.

7.3. Bluetooth Module- HC-05 is a Bluetooth module which is designed for wireless communication. Bluetooth serial modules allow all serial enabled devices to communicate with each other using Bluetooth.



V. COMPONENTS & SPECIFICATIONS

1. Hull-

Fig. Hull of Semi-Automatic Robot

Specifications-

- Raw Material- SS304 Sheet metal
- Length- 1000mm
- Width- 250 mm
- Height- 350 mm

2. Water-wheels

Fig- Water-wheels

Specifications-

• RAW Material- G.S Square Pipes & SS304 Sheet Metal

• Diameter- 500 mm

• Blade Size- 160*160 mm

Fig. Cleated PVC Belt

4.Rollers

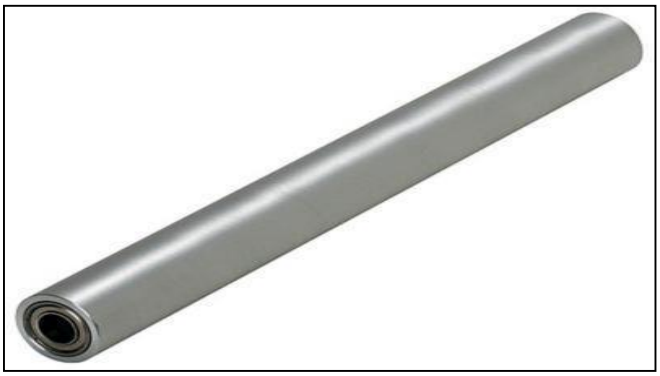


Fig. Rollers

Specifications

• Raw Material- SS304

• Length= 250 mm

• Diameter= 50 mm

5. Shaft

Fig. Shaft assembled with bearing

Length= 300 mm

• Diameter = 20 mm

• Diameter= 50 mm

3.Conveyor Belt

•Bearing Type- Pedestral mounted ball- bearing

6. Battery

Fig. Battery

Specifications-

• Type- Lead Acid

• Operating Voltage- 12 V

• Current- 7.2 Ah

7. Geared Motor-

Fig. Geared Motor

Specifications-

- Geared Type DC Motor
- Working Torque- 5 Nm
- Working Speed- 30 rpm

8. Controller Unit

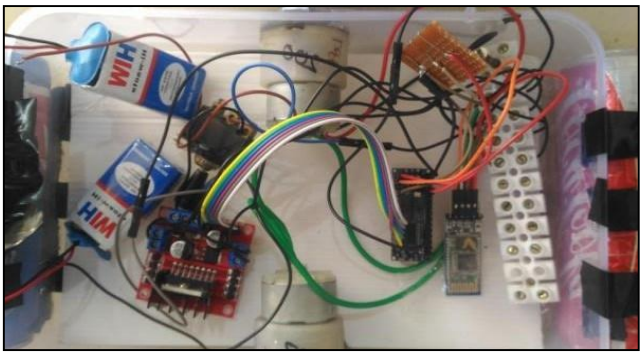


Fig: Control Unit

Specifications-

- Microcontroller- ATmega328p
- Motor Driver- L298 Driver
- Bluetooth Module- HC05

VI. FUTURE SCOPE

• The robot can be used in water quality monitoring and other applications like water sampling, testing & chemical treatment

• The can can be fit with camera and Transmitter and Receiver like Flysky CT6B & FS-R6B so as to enable it to be controlled from long distance.

• Solar panel can be used as a means to charge the battery being used so as to avoid the hassle of charging battery after some time.

• Machine can effectively collect floating solid waste

• The machine is light in weight around 50 kg weight as compared to present river cleaning machine available in market

• Operated by a single operator hence less man power required

• The risk to the worker is eliminated as there is no risk involved in operating this machine

• The machine works on battery so it is environment friendly as opposed to diesel operated conventional machines

• The **machine** is also cost effective as compared to conventional river cleaning machines.

VII. ACKNOWLEDGEMENT

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