

Automated Beach Cleaning Machine

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ABSTRACT-Beaches are one of the main tourist attractions in the coastal parts of India. They are also the most polluted. Most government neglected cleaning of beaches. The main reason being the difficult nature of cleaning it. It takes up lot of resources and time. The workers need to manually pick the waste. The waste when thrown in the sand gets covered with the sand by the heavy coastal winds. This makes the spotting of waste difficult. It is difficult for the workers to clean as they have to dig each cubic feet to collect the waste. The heat and humid climate of the beaches makes the working conditions worse. Many organizations and government bodies are taking several steps to get rid of the waste accumulated in beaches more effectively. India has a long stretch of coastline of about 7517 Km with nearly 170 famous beaches both on eastern and western coasts. Our aim of work is to design and fabricate the beach cleaning machine. We have created a simple economical design so that it will be easy for maintenance and use. The parts have been sourced locally so replacement parts will be easier to get. The machine is environment friendly and can run in any conditions offered by the beach. We have designed and manufactured a beach cleaning machine which is both cheap and easy to use. It does not have a huge learning curve. The machine runs on human power or electric motor. The electric motor is powered by solar panels. This gives an advantage over the current models available in the market which runs in fuel motors. The entire machine is able to fit in the rear of a car.

I. INTRODUCTION

1.1 Need for Technology

The coastal beaches are the main attraction for tourism. To attract tourists, the beach must be kept clean. To clean the beach, some cleaning machine must be used. So we have manufactured a cleaning machine which helps clean the beaches. Today's era is moving towards

being digitalized and automated. The youth want everything easy and smart. Anywhere you go, you get easy technology availability. So we thought of using this technology and adding more to it for our final year project. For that, we are using the system by which a beach cleaner can do his work smartly using technology. So, Beach Cleaning Machine is proposed to overcome real-time problems. One more useful and important advantage of our system is that the worker can replace the manual work at the beach through this semi-mechanical beach cleaner having easy access. The main task in beach cleaning strategies is to find the best way to handle the waste matter, taking into consideration of beach erosion and changing terrain.

1.2 Motivation and Problem Statement

Beaches are recreational areas and attract many local and international visitors through sunbathing, swimming, walking or surfing activities. This coastal tourism is important for many countries because tourism activities contribute to a large facet of their economy. Therefore, a polluted beach or coastline may substantially impact a country's economy negatively. Contaminated beaches have become a global concern since the beginning of industrialization. Contaminated beaches are unattractive for international and local tourists due to aesthetic value or health concerns. According to the study, local and international tourists choose to visit the country because of the beauty of beaches and the proper climate conditions of the country. If the tourists do not find their expectation met on a beach, they can travel to other beaches to find a better one in the country. So, beach cleanliness is very important for countries and the tourism industry nowadays.

1.3 Objectives

The essential objective of the beach cleaning machine is to clean the beaches at a depth as fast and efficient. To reduce the cost of machine and to be able to transport it to most remote

beaches. To procure spare parts locally and should be able to fix by any person who knows basic mechanics. Since the cost of this system is less due to local procurement the machine can be widely used for all the beaches. As the system works on a basic chain and sprocket system maintenance will be very low and it does not require fossil fuel so it can be used in a remote location. This machine works with wide range of operation like removing seaweed, dead fish, shells, wood, and virtually any unwanted debris. The major objective is that, it can work on both wet and dry sand.

II. PROPOSED WORK

2.1 Problem Statement

One of our greatest natural resources has become a garbage dump—and the results are taking a toll on human and marine health. Billions of pounds of pollution end up in our oceans each year, and the majority of it comes from human activities along the coastlines and inland. Litter such as cigarette butts, food wrappers, and plastic bottles can simply be left behind by beachgoers. More indirectly, residential or commercial trash that is not properly disposed of will also eventually reach the beaches. Polluted beaches pose a serious health risk for people who come in contact with dirty water or sand. One study found that people can get sick without even going into the water, contact with polluted beach sand was enough exposure to sicken them. It is estimated that beach pollution affects more than 800 species of wildlife around the world. Considering the seriousness of the problem mentioned above, there

is an utmost need to make the beaches clean so as to avoid Beach pollution and its vulnerable effects on Human and animals. In problem defining, the beaches are the most polluted areas in the coastal regions which are difficult to clean also it takes lot of Efforts, Time and Resources to clean it properly. India has a long stretch of coastline of about 7517 km with nearly 170 famous beaches both on eastern and western coasts. So many Government organizations are investing into a machine that cleans the beaches effectively but this requires huge finance resource. So we have developed a Design Model which will be cost effective and easy to operate.

2.2 Proposed Solution

The basic mechanism of the Proposed Beach Cleaning Machine is the Chain Conveyor mounted on required sprockets. On this Roller chain conveyor, there is an attachment fixed after each 10 Roller chain pitch distance. The jaws are welded at a fixed intervals on the rectangular bars whose ends are bolted to an attachment. These jaws would be the main elements to pick up the garbage or trash from the beach. These whole elements constitute the Chain Conveyor assembly which is the main Working principle of the proposed machine. The Chain conveyor assembly is mounted in an inclined manner on a Frame made up of M S material. The frames are having wheels installed at its base for propelling the machine in forward and reverse direction. The schematic diagram of the proposed machine is shown in figure.

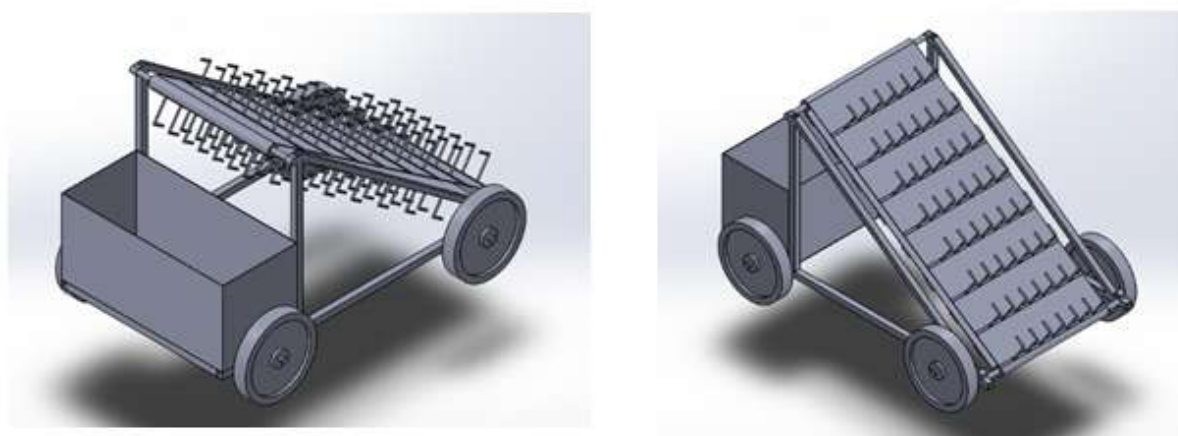


Fig.1 -Assembled Model

III. PROJECT DESIGN

3.1 Required Components

The Beach cleaning machine is manufactured out of several components. Following are the listed components used in Beach cleaning machine -

1) **Raw Mild Steel Material** - The Frames, Jaws and shafts are made up of Mild Steel (Low Carbon Steel). As Mild Steel is a general purpose Fabrication material because of its impressive properties. Mild steel is a type of low carbon steel.

Carbon steels are metals that contain a small percentage of carbon (max 2.1%) which enhances the properties of pure iron. The carbon content varies depending on the requirements for the steel. Low carbon steels contain carbon in the range of 0.05 to 0.25 percent. There are different grades of mild steel. But they all have carbon content within the above-mentioned limits. Other elements are added to improve useful properties like corrosion resistance, wear resistance and tensile strength. The low carbon content makes this steel a highly machinable metal. It can be cut, machined, formed into intricate shapes without adding proportional stresses to the workpiece. It also facilitates better weldability. Some mild steel's physical properties are as follows:

- High tensile strength
- High impact strength
- Good ductility and weldability
- A magnetic metal due to its ferrite content
- Good malleability with cold-forming possibilities
- Not suitable for heat treatment to improve properties

The various dimensions for different Mild Steel elements used in the proposed machine are as follows -

- **Frame** - Hollow Square Pipe of $20 \times 20 \times 2$ mm.
- **Shaft (For mounting wheels and Chain conveyor sprockets)** - Solid rod of 20 mm Diameter.
- **Shaft (For making Jaws)** - Solid rod of 5 mm Diameter
- **Rectangular Bar (For attaching Jaws)** - 15×3 mm.

2) Wheels –For making Machine to move in forward or reverse direction, wheels made up of Polymer material is used. These wheels are having 10 inches Outer diameter and 1 inch hole is provided for mounting it on shaft. It can bear up to 300 kg load and comparatively have less weight.

3) Motor - Since the machine should have a Low speed and High Torque is required to lift the garbage or trash. So a 12V DC Geared Planetary Motor having 50 RPM is selected. A planetary gear motor mimics a planetary rotation system, the input shaft drives the central gear, also known as the sun gear, which then turns the surrounding gears, also known as planet gears. They also feature a very compact, low-weight design in their Class. The details of DC geared Planetary Motor used are as follows -

- Operating Voltage: 12V DC
- Rated Torque: 240 N-cm

- Rated Speed: 50 RPM
- Rated Current: 2.10 A
- Rated Power: 25.12 W
- Gear Ratio: 99.5 : 1

4) Battery and accessories -Hitachi HRL 1234W F2FR Lead Acid CSB Battery having capacity 7.2 Ah and Nominal Voltage is 12V. It is a SMF type Battery and weighs approx. 2.10 kg. The Battery can provide an initial current of 3.4A. Accessories consists of wires, lugs, switches, etc. for operating the Battery as per the requirements.

3.2 Material Load Calculations

The Materials required for making the whole Frame of the Robot are listed below along with their weight calculations,

1) Square pipe :-

- Material: Mild Steel (MS)
- Cross-section: $20 \times 20 \times 2$ mm
- Length: 630 cm = 6.3 m
- Weight per meter: 1.11 kg/m
- ∴ Weight = 1.11×6.3 = 6.993 kg \cong 7 kg

2) Circular Solid Rod :-

- Material: Mild Steel (MS)
- Cross-section: $\varnothing 20$ mm
- Length: 130 cm = 1.3 m
- Weight per meter: 2.5 kg/m
- ∴ Weight = 2.5×1.3 = 3.25 kg

3) Rectangular Bar :-

- Material: Mild Steel (MS)
- Cross-section: 15×3 mm
- Length: 480 cm = 4.8 m
- Weight per meter: 2.5 kg/m
- ∴ Weight = 2.5×1.3 = 3.25 kg

4) Circular Solid Bar :-

- Material: Mild Steel (MS)
- Cross-section: $\varnothing 5$ mm
- Length: 8400 mm = 8.4 m
- Weight per meter: 0.15 kg/m
- ∴ Weight = 0.15×8.4 = 1.26 kg \cong 1.3 kg

5) Conveyer Chain :- 2 kg (Assuming the weight of the Conveyer Chain)

6) Motor + Garbage :- 5 kg (Assuming the weight of the Motor and the Garbage in the Bin)

7) Total weight = $7 + 3.25 + 1.7 + 1.3 + 2 + 5 = 20.25$ kg.

- Considering the Service factor as 20%

∴ Total weight = $20.25 \times 1.2 = 24.3$ kg

Conveyer Chain: Weight

- Excluding Frame, Motor and Garbage weight

∴ Conveyer Chain Weight = Total weight - Weight of Frame + Weight of Motor and Garbage
= $20.25 - (7+5)$
= 8.25 kg.

- Sprocket weight as 1.5 kg

- Total weight = 9.75 kg.
- Considering the Service factor as 20% = 9.75×1.2

∴ Total weight = 11.7 kg ~ 12 kg

3.3 Design of Motor

• Calculation for Propulsion of Beach Cleaning Robot are as follows:-

- Diameter of wheel = 10 inches.
 - Radius of wheel = 5 inches = 0.127 m
- ∴ Torque required = Force × Radius
= Mass × Gravity × Radius

$$= 24.3 \times 9.81 \times 0.127$$

$$= 30.275 \text{ N-m}$$

Now, Power = $\frac{2 \times \pi \times N \times T}{60}$

- Assuming motor speed = 30 rpm (Since the requirement of the Robot is to clean the Beach. Hence, assuming low speed)

$$\therefore \text{Power} = \frac{2 \times \pi \times 30 \times 30.275}{60} = 95.11 \text{ watts}$$

3.4 Design of Chain Drive

Conveyor Design

Transmission Ratio $i = 1$

$$Z_1 = Z_2 = 24$$

Centre distance = 800mm

Pitch = 12.7 mm Standard [PSG – 7.71]

Centre distance in multiple of pitches, $a_p = 800/p = 800/12.7 = 63$

Length of the chain in multiples of pitches,

$$L_p = 2a_p + \frac{(Z_1 + Z_2)}{2} + \frac{(Z_1 - Z_2)^2 / 4a_p^2}{2} \text{ [PSG – 7.75]}$$

$$= 2 \times 63 + \frac{(24 + 24)}{2} + 0 = 150$$

Length of chain, $L = l_p \times P = 150 \times 12.7 = 1905 \text{ mm}$ [PSG – 7.75]

Diameter of sprocket, $d = \frac{P}{\sin(180^\circ/Z_1)} = \frac{12.7}{\sin(180^\circ/24)} = 97.29 \text{ mm} = 4 \text{ inch}$ [PSG – 7.78]

3.5 Design of Welded Joint

Selecting Mild Steel of Grade 15 having $\sigma_t = \sigma_b = 450 \text{ N/mm}^2$

Taking Type of weld as Fillet Weld

$$\therefore \sigma = \frac{5.56 M_b}{h D^2 \pi} \dots \dots \dots \text{ [PSG – 11.3]}$$

$$M_b = \text{Load} \times \text{Distance}$$

$$M_b = 300 \text{ N} \times 70 \text{ mm} = 21000 \text{ Nmm}$$

$$\sigma = \frac{5.56 \times 21000}{3 \times 20^2 \pi} = 31.53 \text{ N/mm}^2$$

$$\therefore \sigma < [\sigma_b]$$

Hence, Design is safe in bending.

IV. IMPLEMENTATION AND FABRICATION

4.1 Implementation

The major objective of this research work is designing the beach cleaner, by considering various factors which will influence the performance of the machine. The model is fabricated and the model is assembled, and then the procedure is studied and optimization is done for effective semi-automatic wireless controlled beach cleaner. In this research work the major task of this equipment is to remove the trash from the surface of the beach and discard them in the tray. Here we are fabricating the river cleaning machine which is remote operated. The chain drives and collecting plates are rotating by the motor continuously. A collecting plate which is coupled between the two chains drives for collecting the materials which are waste from river. The wastes which are collected are thrown on the collecting tray with the use of conveyer. Our research work is having DC motor with wheel arrangement which is used to control the model.

This research work consists of a wheel which is operated by motor. It is having three Direct current Motor. The machine used for operating the model is a drive which is of chain type and is having a collector plate. The model is having two shafts. The Shafts are used for the purpose of hoisting and to balance the chain drive sprocket. The parts resting on the structure is the important feature of the model. The steel pipe with connection of dc motors will run the model even in irregular surfaces. The collecting tank is used to stock the debris satisfying the principle of the machine.

Selection of Chain Drive and Sprocket

Determine the velocity ratio of the chain drive Ratio of Velocity = S_1 / S_2 So, $S_1 / S_2 = T_2 / T_1$, Ratio of Velocity = 1 Choose the least number of teeth on the smallest pinion or sprocket. Least number of teeth on the Sprocket = 18. Taking number of teeth on sprockets as 24.

A. Permanent Magnet DC Motor

30 RPM center shaft Direct Current motor is geared to a DC motor which is of high quality and low in cost. It is having gears and pinions are made of steel material to assure longer life and to withstand wear and tear. The gears are having mirror finish and they are fixed on spindles which are of steel material. The shaft used for output is rotating in a bushing of plastic material. Ring made of plastic material covers the assembly. Gearbox requires low maintenance.

B. Wheel

A wheel rotates on a bearing which is axial. The wheel is the key part of the wheel and axles. Wheels combining with axles are used to

transport or move a heavy weight, support a load and perform labor in machines

4.2 Fabrication

The beach cleaning machine is fabricated with mild steel rectangular tube section frame. The main factor in choosing the rectangular tubing section is to reduce the weight of the entire machine. As weight reduction enable the machine to be carried very easily. The spokes were made by cutting long steel rods and bending it by placing it on a vice. The steel rods were selected because they can resist huge loads. The spokes are welded on the steel plates which in turn are bolted on the special provision (attachments) provided on the chain. Long plates are cut into 11"x 3" size for placing the spokes. Small holes are cut into the plate in order to have additional weight reduction. Chains and sprocket were selected based on the calculation. Pedestal bearing is used to hold the rotation shaft on which sprockets were mounted. Motor is mounted on the upper sprocket shaft. The below diagram shows the final assembly of the beach cleaning machine. All common fabrication techniques such as welding, drilling, cutting, buffing and bending were used. The primary tubular frame structure required the applications of welding and cutting techniques. The dimensions of the rectangular frame are as follows: 27.5 × 17.5 inches. The height of the frame is about 32 inches within which the handle bar arrangement has been fixed. M8 drill bit has been used to fix the handle

bar arrangement to the frame. The inclined triangular structure used to support the shafts is of dimensions 28 × 25 × 10 inches which resembles a scalene triangle. Two links of size five inches each are positioned on either side of the rectangular frame on predestinated points. The battery mount of dimensions 5 × 3 × 3.5 inches is seated comfortably on the left hand side of the rectangular frame. The shaft supports were also attached to the tubular structure using welding. M10 drill bits were used to fix the pillow blocks. There are two sets of pillow blocks; each set of pillow block supports one shaft of length 23 inches. Each shaft houses two plain bored sprocket of 3 inches diameter containing 24 Teeth which are situated at a distance of 13 inches apart from each other, thus making it two inclined pairs. Each inclined sprocket pair houses a specialized K2 chain of 45 inches long. Combined together, the chains have twelve pairs of plates (two M4 holes) attached to their links. Claw supporters are bolted strategically to the plates of the chain, so as to house fifteen fully functional claws for rag picking. For facilitation of easy rotation, the motor has been attached on the left hand side of the upper shaft. A flexible housing compartment has been used to hold the motor in place and it will also comfortably aid in the fixing and removing of the motor. The Arduino setup has been placed right below the motor thereby enabling us to prevent complex wiring. The battery motor and Arduino setup helps in automating the rotation of the shafts.



Fig.2 - Final Assembly

V. CONCLUSION

Thus a prototype beach cleaning machine is successfully designed and fabricated. This machine has been manufactured by employing various fabrication techniques. This machine will play an important part in reducing human effort and keeping the environment clean at a minimalistic expense. India has a coastline of about 7517 km long. It is the responsibility of the Government of India and the citizens to keep the coastline free from debris and to protect the marine ecosystems. This machine helps in cleaning the beach with the state-of-the-art technology which would be earlier cleaned by manual workers and they are being affected by the hazardous garbage and thereby saves the ocean life from pollution. Since the cost of this system is less due to local procurement the machine can be widely used for all the beaches. As the system works on a basic chain and sprocket system maintenance will be very low and it does not require fossil fuel so it can be used in a remote location. This machine works with a wide range of operation like removing seaweed, dead fish, shells, wood, and virtually any unwanted debris. It can work on both wet and dry sand. As the plates are screwed to the chain, we can remove the plate and fix the screen so that very fine debris can be removed. When this system is powered by the solar power it has the advantage of harnessing the natural resources thereby the machine becomes environmental friendly. This system helps to clean beaches so it keeps the sand clean and saves the ocean life from garbage pollution. This system does not need more human labor for the waste water cleaning and this can reduce the direct contact of the human labor with the waste water so there is no hazard for the human labor. Also, this method is automatic so the working time is less as compared to the conventional method. Because of this project as there is no direct contact of the worker with garbage, the health of the worker will be good and he will be able to work for a longer duration. This system is fabricated with emphasis on the use of local materials and local production.

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