Design and Fabrication of Beach Cleaning Machine

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Abstract*: The beach cleaning machine is a vehicle that can be used to pick up rags from the shores thus keeping the beaches clean. A great number of people visit beaches very often for relaxation and recreation. People throw plastics quite often on shores without knowing the consequences. This results in environmental pollution which affects the marine environment and increases the risks of diseases. In order to overcome this we have designed and fabricated a beach cleaning machine that will clean the beaches by picking up rags with minimal human effort. Here, we have incorporated an Arduino board and developed an app through which we will be able to control the operations of the machine within a range of 10 meter through Bluetooth. A 3-D model of the design has been developed and analysis has been performed. The machine developed is a cost efficient vehicle with high efficiency and also user friendly.

Keywords* : Beach Cleaning Machine, Internet of Things, Arduino UNO.

I. INTRODUCTION

Most of the vehicles in the market today cause pollution and fuel cost are also increasing day by day. In order to compensate the fluctuation of the fuel cost and the increasing levels of pollution a sustainable mean of transport is required. This vehicle is for a single person who has difficulty in going places such as differently abled or elder people. A person with such difficulties will be able to drive the vehicle without any dependencies. In order to reduce pollution and help these cases, This vehicle is a feasible solution.

This is a "THREE WHEELED HYBRID VEHICLE" where single power drive is the prime mover which is used to drive the vehicle. Another important reason is to achieve effective power supply for the vehicle and to save the environment including men, machine and material of both existing and the next generation from pollution. Zero emissions are caused since only forms of electrical energy is used.

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II. EASE OF USE

A.Background

Sandy beaches comprise three-quarters of the world's coastlines. Consequently, sandy beach organisms must be included in any comprehensive program of environmental monitoring. Yet, beaches have received relatively little attention on pollution studies, due in part to their seemingly uniform appearance and in part to the difficulty of studying that dynamic habitat. Human activities are responsible for a major decline of the world's biological diversity, and the problem is so critical that combined human impacts could have accelerated present extinction rates to 1000–10,000 times the natural rate. One particular form of human impact constitutes a major threat to marine environment is the pollution by plastic debris. Hence there is an alarming need for a solution to overcome these issues; if not there might be an increased loss in diversity.

B. Scope

In future, for further development we can connect a number of machines with the parent machine and multiple machines can be operated simultaneously using the same command which will further reduce human indulgence. With the incorporation of sensors we will also be able to segregate organic and plastic wastes.

III. WORKING PRINCIPLE

The beach cleaner works on the basis of rotation of the chain and sprocket set. A low speed high torque motor is attached to the upper shaft that drives the sprockets. The lifter mechanism consists of a chain sprocket arrangement coupled to the motor to drive the cleaning mechanism. The torque developed in the motor aids the claws in picking the rags from the sand. In addition to the torque, centrifugal force also acts on the chain. Due to the centrifugal force the chain will move away from the point of rotation that aids in smooth movement of chain over the sprocket

A. Literature Review*:*

Extensive research has not been carried out on beach cleaning machines because they are not widely used and the alternatives available in the market are quite less. According to Quitrakul and Watanasophon (2014), service machines for the purpose cleaning pools and households are being developed continuously but a cleaning machine for the beaches are not given much of an importance. The model developed comprises of a shovel with holes which picks the rags and leaves the sand behind. This model also consists of an IP camera with sensors which detects the wastes and picks them.

Quitrakul and Watanasophon state that with less attention given to cleaning the beaches we are not aware of the high necessity needed to keep them clean. This will affect the environment and also cause harmful effects to the marine ecosystem.

Another model considered during the fabrication was the model developed by Ichimura and Nakajima (2018). This model uses the mechanism of a broom and dustpan and moves autonomously and collects the waste can that is stored in a refuse bin. This model uses a chain conveyor for the purpose of collection of trash and crawlers for the purpose of locomotion.

The model we have developed incorporates principles from both these models. Even though these models exist they are quite complicated to use and requires a technically sound person to operate them. The design of model in developed in such a way that even a layman with no technical knowledge can operate it with ease.

IV. DESIGN

Fig 4.1 3D Model of Proposed System

A.DESIGN SPECIFICATIONS

DIAMETER: 1 INCH
THICKNESS: 2MM
LENGTH: 27.5 INCHES
BREADTH: 17.5 INCHES
HEIGHT: 37 INCHES

B.Components specifications

- Claw Dimensions:

☐ Total height: 10 inches

☐ Segmented dimensions: 5 x 2.5 x 1.5 inches

- Claw plate:

☐ Length: 12 inches

☐ Effective work area: 9 inches

- Sprocket Dimensions:

☐ Pitch: 5/8 inch

☐ No. of teeth: 15

☐ Size: around 3 inches

- Sprocket shaft:

☐ Diameter: ¾ th inch

☐ Length: 2 inches

☐ End gap: 1 inch

- Wheel Dimensions:

☐ Diameter: 20 cm

☐ Shaft diameter: 1 inch

☐ Thickness: 2mm

- Chain Dimensions:

☐ Centre to Centre distance:

☐ Horizontal:13 inches

☐ Inclination: 18 inches

☐ Length of chain: 45 inches

☐ Type of chain: Specialized Chain k2

V. COMPONENTS USED

A.DC Motor

The motor which we have used is a windscreen wiper motor which is also known as Ferrite magnet type motors as permanent magnets are used in them. The armature coils in the wiper motor generate a counter-electromotive force when it is operated which controls the speed of rotation of the motor. The motor of the wiper operates when high or low current flowing through the Windscreen wiper-motor passes through Hi/Lo position of the wiper switch along with the voltage of the battery. This motor is low speed high torque motor which aids the claws in holding the rags firmly.

Fig 5.1 DC Motor

B.Chain

The chain used here is specialized K2 chain. These chains are provided with attachments to which the claw plates can be bolted.

Fig 5.2 Chain

C.Pillow block

A pillow-block is a platform utilized to offer backing for a revolving shaft with the aid of well-suited bearings & several accessories. Housing material for a pillow-block is classically

made-up of cast iron or cast steel. A pillow-block denotes to any riding bearing in which the riding shaft is in a parallel plane to the mounting surface, and perpendicular to the center line of the mounting holes, as contrasted with various types of flange blocks or flange units. A pillow block may contain a bearing with one of several types of rolling elements, comprising ball, cylindrical roller, spherical roller, tapered roller, or metallic or synthetic bushing. The kind of rolling element describes the form of pillow block.

Fig 5.3 Pillow Block

D.Vehicle Frame:

The material used for the fabrication of the primary frame is ASTM 106 Grade B MS pipes. ASTM A106 Grade B is a mild steel pipe material commonly used in industrial plants, power plants, refineries and chemical plants which is typically seamless and comes in three grades A, B, and C with grade B being the most commonly used grade.

Fig 5.4 Vehicle Frame

E.Ardunio UNO:

The Arduino UNO is an open-source microcontroller based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 Digital pins, 6 Analog pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It can be powered by a USB cable or by an external 9 volt battery, though it accepts voltages between 7 and 20 volts.

Fig 5.5 Arduino UNO

F. Sprocket:

A sprocket/sprocket-wheel is a profiled wheel with teeth that meshes with a chain, track or further perforated material. The sprockets used here are plain bored sprockets. Plain bores, often referred to as minimum plain bores or MPB, are simply untapered bores drilled through the center of a pulley, gear, sprocket, or sheave. Sometimes component part numbers use MPB to designate the plain bore style.

Fig 5.6 Sprocket

G.Bluetooth Module

Bluetooth is a wireless technology standard for exchanging data between fixed and mobile devices over short distances using short-wavelength UHF radio waves in the industrial, scientific and medical radio bands, from 2.400 to 2.485 GHz, and building personal area networks. It was originally conceived as a wireless alternative to RS-232 data cables. Bluetooth is managed by the Bluetooth Special Interest Group (SIG), which has more than 30,000 member companies in the areas of telecommunication, computing, networking, and consumer electronics. A manufacturer must meet Bluetooth SIG standards to market it as a Bluetooth device. A network of patents apply to the technology, which are licensed to individual qualifying devices.

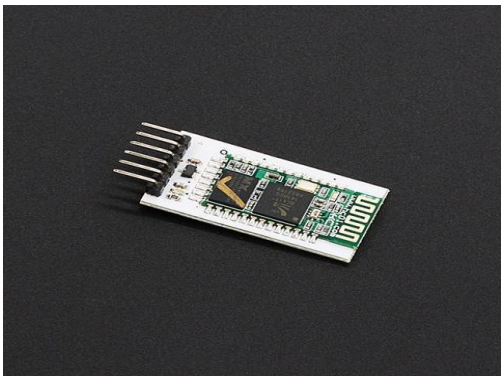

Fig 5.1 Bluetooth Module

VI. FABRICATION PROCESS

For the purpose of accomplishing the designated mission for the machine, the mechanical design was subdivided in different modules. Each module was designed with a specific task, which allows an efficient and practical way to manufacture, test and repair the components, maintaining the proposed model. The principal mechanical components of the machine are the body, drive train and wheels.

A. Part description:

The base rectangular chassis consists of four rubber wheels for the purpose of locomotion. A lower shaft is fixed on to a pipe which is at an inclination of 60 degrees. The lower shaft is provided with two plain bored

sprockets. Similarly an upper shaft is also fixed to the same inclined pipe. The upper shaft is also provided with two bored sprockets and also provided with an attachment to which the motor shaft can be fixed for rotation. The motor used is a car windshield wiper motor which rotates the upper shaft. As the upper shaft is rotated due to chain sprocket setup the lower shaft is also rotated. A vertical member is also fixed to the frame to support the handle bar. The handle bar is fixed at an optimum height which is made adjustable to match the height of the user. A specialized K2 chain is used to hold the claw support. Each claw supporter consists of three claws which facilitate in picking the rags.The batteries are placed at the bottom for the ease of motor operation.

B. Fabrication techniques

a) Metal fabrication process: Metal fabrication is the creation of *metal* structures by cutting, bending, and assembling processes. It is a value-added process involving the creation of machines, parts, and structures from various raw materials.

b) Drilling: It is a cutting process that utilizes a drill bit to cut a hole of circular cross-section in solid materials. . Drilling may affect the mechanical properties of the work piece by creating low residual stresses around the hole opening and a very thin layer of highly stressed and disturbed material on the newly formed surface. This causes the work piece to become more susceptible to *corrosion* and *crack propagation* at the stressed surface. A finish operation may be done to avoid these detrimental conditions.

c) Fabrication work

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 x 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 x 25 x 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 5x3x3.5 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 14 teeths 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.

E.Analysis:

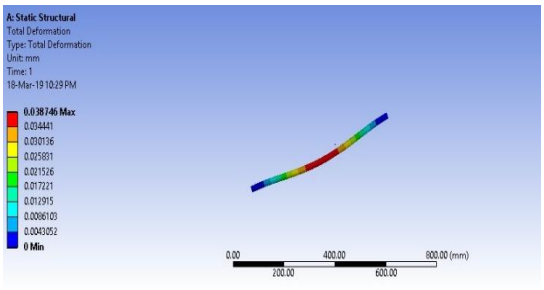

Fig 6.1 Total Deformation

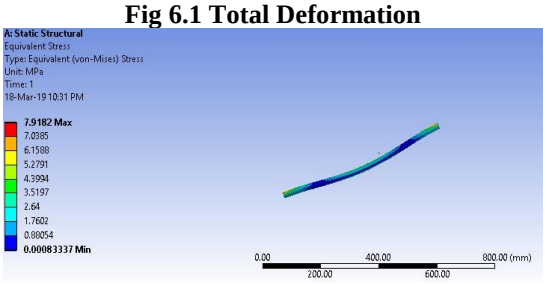

Fig 6.2 Equivalent Stress

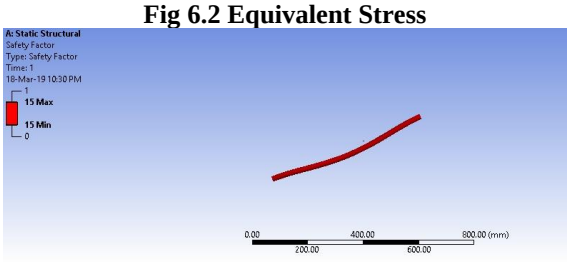

Fig 6.3Factor of safety

Calculation:

Pinion sprocket diameter = 76.2 mm
Wheel sprocket diameter = 76.2 mm
Number of teeth on wheel sprocket = z2 = 15
Number of teeth on pinion sprocket = z1 = 15
Center distance = a = 457.2 mm
Transmission ratio = z2 / z1
= 15/15
= 1

Standard pitch:
Max pitch = a / 30
= 457.2 /30
= 15.24 mm
Min pitch = a / 50
= 457.2 / 50
= 9.144 mm
Standard pitch = 15.875 mm

Actual length of chain:
Approximate center distance in multiples of pitches = Ap = a / p
Ap = 457.2 / 15.875
Ap = 28.8
Length of chain in multiples of pitches / = Lp = (2 * Ap) +[(z1 + z2) / 2] + [((z2 – z1) / 2π)^2 / Ap]
Approximate number of links
Lp = (2 * 28.8) + [(15+15) / 2] + [((15-15) / 2π)^2 / 28.8]
Lp = 72.6 ≈ 72
Length of chain = L = Lp * p

L = 72 * 15.875 = 1143 mm

F.Advantages:

- ❖ Automatic cleaning and trash collection.
- ❖ Manually steered for convenient usage.
- ❖ Ease of burden.
- ❖ Reduces time and human effort.
- ❖ Increases efficiency and helps in maintaining cleaner environments at lower costs.
- ❖ No alternatives in the market and unique design.

G.Limitations

☐ Garbage has to be manually disposed from the machine.

☐ The vehicle is to be manually moved.

H.Applications

☐ Helpful in keeping the beaches clean

☐ Removes most of the plastic wastes making the surrounding plastic free.

☐ Can be used in parks or other public places to clean the sand.

I.Cost Estimation

Table 6.1 List of Components

Sl.No	Component	Quantity	Cost
1	Motor	1	Rs. 1500/-
2	Pillow Block	4	Rs.1000/-
3	Sprocket	4	Rs. 600/-
4	Chain	1	Rs. 1800/-
5	Battery	1	Rs. 1200/-
6	Wheels	4	Rs. 1000/-
7	Paint	2	Rs. 450/-
8	Pipes	6m	Rs. 570/-

VII. 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 kms long.It is the responsible of the Government of India and the citizens to keep the coastline free from debris and to protect the marine ecosystems.

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AUTHORS PROFILE

R.Ramamoorthi is presently working as a Professor in department of Mechanical Engineering. His area of research includes Design, Manufacturing & Analysis of Nano Composites, Optimization Techniques & Analysis of Mechanical components. and friction stir welding and He is a member of various Professional bodies.

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