International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 08 Issue: 05 | May - 2024 SJIF Rating: 8.448 ISSN: 2582-3930

DESIGN AND FABRICATION OF BEACH SAND CLEANER

Dr.Prathamesh S. Gorane[1], Dr. Vijay B. Roundal[2], Dr. Ritesh S. Fegade[3], Avdhut A. Lone[4], Pallavi T. Asawale[5], Dipali P. Deshmukh[6], Nana D. Kadam[7]

[1]Assistant Professor, Department of Mechanical Engineering, GS Moze COE, Balewadi, Pune, India.
[2]Assistant Professor, Department of Mechanical Engineering, GS Moze COE, Balewadi, Pune, India.
[3]Assistant Professor, Department of Mechanical Engineering, GS Moze COE, Balewadi, Pune, India.
[4]Student, Department of Mechanical Engineering, GS Moze COE, Balewadi, Pune, India.
[5]Student, Department of Mechanical Engineering, GS Moze COE, Balewadi, Pune, India.
[6]Student, Department of Mechanical Engineering, GS Moze COE, Balewadi, Pune, India.
[7]Student, Department of Mechanical Engineering, GS Moze COE, Balewadi, Pune, India.

Abstract –

Beaches, while among the top tourist destinations in coastal India, suffer from significant pollution, often neglected by the government in terms of cleaning efforts due to the challenging nature of the task. The problem lies in the way waste gets buried in the sand by strong coastal winds, making it hard to detect and remove. Cleaning requires either manual labor, volunteers, or expensive machinery, all of which are time-consuming. To combat this, our project focuses on designing and constructing an affordable and easy-to-maintain beach cleaner that operates effectively in various beach conditions. Our solution efficiently removes litter by filtering the sand and depositing debris into an attached mesh, presenting an environmentally friendly and economical option for beach cleaning.

Key Words:
Beach sand cleaner, Design and fabrication.

1. INTRODUCTION

Beach pollution has emerged as a widespread concern affecting both human and marine life, posing significant environmental repercussions. Coastal areas, crucial for ecological balance and recreational purposes, face pollution from various sources such as damaged wastewater infrastructure, illegal dumping, oil spills, and litter left by individuals. Non-biodegradable materials like plastic, rubber, and metals pose enduring threats, taking centuries to decompose. Aquatic creatures often ingest these materials, leading to fatalities. The continuous deposition of plastic on beaches exacerbates the issue, with marine life ingesting plastic particles, ultimately impacting human consumption. To address this, mechanized debris collection methods are necessary. Our eco-friendly beach cleaner filters and collects debris efficiently into a mesh, mitigating the adverse effects on coastal ecosystems.

2. Literature Review

Design and Manufacture of Beach Cleaning Vehicle [1] - The purpose of this project is to design and create a functional beach cleaning device that can be used for beach maintenance. This machine enables the entire beach cleaning process. This reduces the cost and labor required to maintain the beach. Our main goal is to create a machine that is both practical and affordable. The ability of our device to fit well in the trunk of a car is another of its most

important features. The whole machine is green and local suppliers are available for spare parts.

Design and manufacture of beach sand cleaning machine [2]- The beach sand cleaning machine takes out or drags sand and then rakes or sieves any foreign matter large enough to be read in. bucket or storage container, including sticks, debris, wrapping, polythene, etc. A similar machine is also used on the shore of the lake, on private sand yards, in the garden and in the sandboxes of sports fields. The main purpose of this machine is to separate the garbage from the sand and collect it in a bucket to make the area convenient and visually pleasing to people.

Malaysia Sabah University Beach Cleaning Machine Prototype Design and Analysis (UMS) [3] - This paper designed and developed a beach cleaning machine suitable for Kota Kinabalu for local shore profiles. From the point of view of a clean future, beach cleaning is essential to collect trash from the beach with a simple and practical design and at the same time create an ecological, user impact. This work developed a custom-made beach cleaning machine that includes a local manufacturer and mechanical equipment such as a collector, a conveyor, 14 motors and gears using one-man-screen-scraping systems.

Eco Beach Cleaner [4] - The main goal of this project was design a small enclosed machine that uses solar energy with the help of solar panels (making it environmentally friendly) and helps collect garbage from coastal areas, ie. sandy beach, into a well. an organized place. way and keep in trash and also minimize labor cost.

Design and Fabrication of Beach Cleaning Machine C. Balasuthanagar, Dinesh Shanmugan [5] - In this machine they have automated river cleaning machine using motor and chain drive mechanism. It is remotely controlled with a radio frequency modulation receiver and transmitter.

Designing a beach cleaning machine [6] -Within this project, a functional beach cleaning machine is designed and developed. This machine allows general beach cleaning. This reduces the cost and labor involved in beach cleaning. The focus is to develop a machine in a pragmatic way that is both cheap and easy to use. The waste is collected through the conveyor blade. It consists of a belt that moves and collects waste, and the collected material is pulled into a box.

3. WORKING PRINCIPLE

Litter Picking: (Large Debris In The Sand, Ex : Cans,Bottles)

1. The equipment is pushed by human effort. When the wheels rotates it moves forward, pushing the debris inside.
2. The rakes attached on the wheel lifts the debris onto the apron till the very top from where it directly falls into the perforated mesh.

Sand Sifting:

1. A geared motor is is connected to the gear and sprocket rotary mechanism.
2. The motor is powered by a battery and the motor is switched on with the help of switch button present on the hand of the equipment for easy on/off.
3. A shaft coupled with a motor rotates at a certain speed. The drum has flaps attached on it.
4. The flappers brushes off the top layer of the sand along with small or medium debris present in the sand.
5. The sand particles along with the debris gets carried due to the rotation of the flappers and falls on the perforated mesh.
6. The mesh has perforations small enough to allow sand particles pass through it and stop the debris.
7. The debris is then collected in the mesh and the sand particles again fall down.

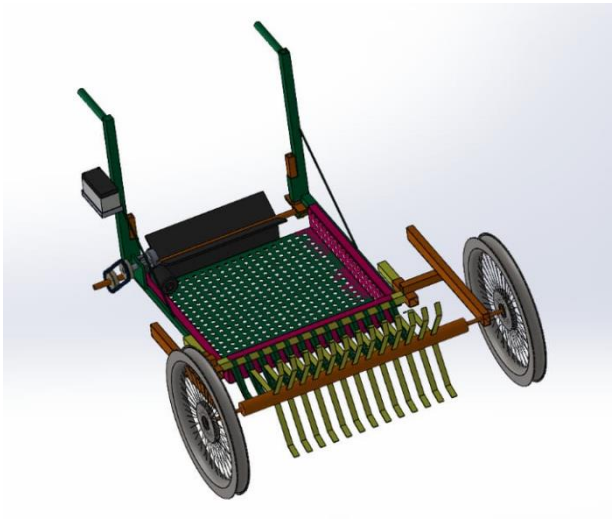

Fig: Isometric view of Beach Sand Cleaner

4. COMPONENTS OF BEACH SAND CLEANER

A. Square Frame:

The frame uses rectangular steel profiles. Rectangular pipes have many advantages. They offer a pleasing appearance, excellent strength-to-weight ratio, uniform strength, cost-effectiveness and recyclability. The advantages of using rectangular tubes are as follows. They offer a higher strength-to-weight ratio. Rectangular tubes reduce the weight of steel needed to do the job, reducing costs. Rectangular tubes are particularly suitable for all types of applications due to their high strength, excellent compression and tug properties and exceptional durability. Rectangular steel pipes are made of steel, which is one of the most recycled and recycled materials in the world. Because of their torsional strength, steel rectangular tubes are a great way to carry durability and flatness.

B. Rake:

It is used to remove debris from the sand. It is created by first cutting long rods attached to steel structures and then bending them in a vise. Surfaces were made of stainless steel for the following reasons: they are very strong, resistant to corrosion, thermal damage, chemical damage.

C. Wheels:

The wheels are used to move the equipment forward and backward. The wheels are fitted with bearings to smoothen the operation. The wheels are made of steel or alloy.

D. Chain and sprocket:

The wheels are used to equipment forward and backward. The wheels are fitted with bearings to smoothen the operation. The wheels are made of steel or alloy.The sprockets are used to transmit power from one component to another through chains. A sprocket is a wheel that has a textured pattern of teeth on a chain, track or other material with holes or indentations. Any wheel which have radial projections and a chain, ose above it, is usually called a gear. It differs from a sprocket in that the sprockets never mesh directly with each other and rollers are smooth while the gears have teeth.

E. Perforated Mesh:

Perforated metal is a special metal sheet with holes in different patterns - or as we call it, design, character and function. Perforated mesh is used in sand filtration equipment. The perforated mesh used in this device is made of mild steel and stainless steel.

I. Lead acid battery:

The lead-acid cell is the type most commonly used. The electrolyte is a dilute solution of sulfuric acid (H_2SO_4). In the application of battery power to start the flapper. One cell has a nominal output of 2.1V, but lead-acid cells are frequently used in a series combination of three for a 6V battery and six for a 12V battery.

J. Flapper:

The flappers are made of sheetmetal which are cut in rectangular shape. Three sheets are hinged joint on a shaft. They are

powered by motor through shaft. The flappers rotate at a certain speed to lift the sand and small debris and throw it in perforated mesh.

K. Motor:

A gear motor is a component that has a mechanism that regulates the speed of the motor and makes them work at a certain speed. gear motors are able to produce high torque at low rpm because the gearbox acts as a torque multiplier and allows small engines to produce higher speeds. A gear motor can also be defined as a gear reducer because it is basically a combination of a speed limiter, which is usually an engine that acts as a gearbox changes to reduce the speed, leaving more torque.

5. Methodology:

Methodology for the Design and Development of Beach Sand Cleaner System:

1. Problem Identification and Requirements Analysis:

Identify the specific challenges and requirements associated with beach sand cleaning, considering factors such as the type and volume of debris, beach terrain, environmental conditions, and operational constraints.
Conduct a thorough analysis of existing beach cleaner systems and technologies to understand their strengths, limitations, and opportunities for improvement.

2. Conceptualization and Design Planning:

Develop conceptual designs and engineering specifications for the beach sand cleaner system, outlining the desired functionalities, performance targets, and design parameters.
Determine the key components and subsystems required for the system, including the wiper motor, chain sprocket mechanism, perforated mesh bin, flapper mechanism, and rake functionality.

3. Component Selection and Integration:

Evaluate available components, materials, and technologies for each subsystem of the beach cleaner system, considering factors such as durability, reliability, efficiency, and compatibility with the overall design.
Integrate selected components into a cohesive system design, ensuring proper alignment, connectivity, and functionality of each subsystem.

4. Mechanical Design and Engineering:

Utilize computer-aided design (CAD) software to create detailed mechanical designs and 3D models of the beach cleaner system components.

5. Fabrication and Testing:

Fabricate prototype versions of the beach cleaner system components and subsystems using rapid prototyping techniques, machining, and fabrication processes.
Conduct comprehensive testing for evaluating its performance, durability, efficiency, and user-friendliness.

6. Iterative Optimization and Refinement:

Gather feedback from testing results, user evaluations, and stakeholder input to identify areas for optimization and refinement in the beach cleaner system design.
Iterate on the design, making iterative improvements to address identified issues, enhance performance, and optimize functionality.

7. Documentation:

Document the design specifications, fabrication processes, and performance outcomes of the beach cleaner system.

6. Calculations:

1. DESIGN OF MOTOR -

Power of motor = 30 N- m /s. 12 V

Rpm of motor = 100 rpm

CALCULATION OF TORQUE

Power of motor = P = 30 watt.

$$P = \frac{2\pi N T}{60}$$

Where,

N→ Rpm of motor = 100 rpm

T →Torque transmitted

$$30 = \frac{2\pi \times 100 \times T}{60}$$

T = 2.86 N-m

T = 2860 N-mm

2. DESIGN OF SHAFT -

Now, Chain Sprocket of 36 And 36 Teeth Is Mounted

So, ratio: 1

T2 = 2680 N-mm

N2 = 100 rpm

Now, T1 is the maximum torque among all shafts, so we will check shaft for failure here.

$T=\pi/16 \times 135 \times d^3$

$d^3=2860 \times 16 / 3.142 \times 135$

$d=3\sqrt{108}=4.76=5$ mm

but we are using- 20 mm shaft so design is safe.

3. DESIGN OF BEARING -

For 20mm Shaft diameter we take standard breaking no. P204

P=Pedestal bearing

2=spherical ball or deep groove ball bearing

=04=5 * 4 = 20mm

Bore diameter of bearing = 20 mm

4. DESIGN OF SPROCKET

TRANSMISSION RATIO = Z2 / Z1 = 36/36 = 1

PITCH OF SPROCKET
P = 6.35mm

Dia. Of sprocket = ?

Periphery = π × dia. Of sprocket

36(teeth) × 6.35 (pitch) = π × D

D = (36 × 6.35) / π

D = 72.76 mm

5. DESIGN OF SQUARE FRAME -

M = W L / 4 = 300 x 750/4=56250 N/mm

$Z = B^3 – b^3 / 6 = 30^3 - 26^3 / 6 = 1570.66\ mm^3$

$\sigma_b = M / Z$

$\sigma_b = 56250 / 1570.66 = 35.81\ N/mm^2$

$\sigma_{b\ INDUCED} < \sigma_{b\ ALLOWED}$

$35.81\ N/mm^2 < 270\ N/mm^2$

Hence our design is safe.

6. DESIGN OF BOLT FOR SHEAR STRESS FAILURE-

Bolt is to be fastened tightly also it will take load due to rotation. Stress for C-45 steel.Standard nominal diameter of bolt is 9.31 mm. From table in design data book, diameter corresponding to M10 bolt is 8 mm

Let us check how much load bolt can sustain -
P =? N is the value of force
Stress = load/area

$\sigma = \frac{P}{A}$

$A = \frac{\pi}{4}d^2$

$A = \frac{\pi}{4} 8^2 = 49.98$

$P = 135x49.984$

P = 6747.84 N = 687 kg

The calculated load is much higher than any applied load, hence our design is safe.

7. CALCULATION OF FORCE OF RUBBER FLAPPER -

T = Force × radius

2680 = F× 110

F = 24.40 N

This is the force lifted by rubber flappers

8. CALCULATION OF BATTERY (NO. OF WORKING HOURS) -

Battery 12v 7.5 amp = 90 watt

15 x 4= 60 watt

90/60= 1.5

60x1.5 = 90 min

9. CALCULATION OFFRONT WHEEL –

Let the operator is operator is pushing the machine with 5 km/hr speed.

So, V = 1.39 m/s (1 m/s = 3.6 km/hr)

Diameter of wheel is 540 mm

$V = \pi DN/60$

V= 3.142 x 0.54 x N/60

N = 1.39 x 60/3.142 x 0.54

N = 49.16 rpm

When considering human-powered equipment, a healthy human can produce about 1.2 hp is 895.2 watt.

$P = 2\pi NT/60$

895 = 2 x 3.142 x 49.16 x T/60

T=173.83 N-m

T =173831 N-mm

$T_e = \pi/16 \times 160 \times d^3$

$d^3 = 173831 X 16/ 3.142X 135$

d=18.71 mm

but we are using-20 mm shaft so design is safe.

For 20mm Shaft diameter we take standard breaking no. P204

Torque transmitted,

T = Force × Length

173831 = F× 200

F = 869.155 N

This is the force lifted by front wheel main.

10.CALCULATION OF MAXIMUM TENSION ON CHAIN

As we know maximum torque on shaft = T_{max} = 2860 N-mm

Where,

T1 = Tension in tight side

T2 = Tension in slack side

O1, O2 = center distance between two sprocket

From fig.

$\sin \propto = \frac{R1 - R2}{O1O2}$

$\sin \propto = \frac{36 - 36}{130}$

$\sin \propto = 0$

$\propto = 0$

TO FIND θ

$\theta = (180 - 2\propto) \times 3.14/180$

$\theta = (180) \times 3.14/180$

$\theta = 3.142$ rad

we know that,

$T1 / T2 = e^{\mu\theta}$

$T1 / T2 = e^{0.35 \times 3.142}$

T1 = 3 T2

We have,

T = (T1 – T2) X R(NO of teeth of sprocket)

2685 = (3T2 – T2) X 36

T2 = 36.902 N

T1 = 3 x 36.902

T1 = 110.7 N

So, tension in tight side = 3035 N

Stress = (force/2) / area

Stress induced =$110.7 / (3.14 * 3.96^2 / 4) \times 2$

Stress induced = 4.50 N /mm^2

As induced stress is less than allowable stress = 135 N /mm^2 design of chain drive with sprocket is safe.

11. CALCULATION OF RAKE LOAD -

F = maximum force applied =? N

For cantilever, M = F x L

M = F x 200 = 200 F N-mm

And section modulus = Z = 1/6 bh^2

$Z = 1/6 \times 5 \times 25^2$

Z = 1/6 x 3125= 520.8 mm^3.

Now using the relation,

Fb = M / Z

270 = 200 F/ 520.8

F=703.08 N

But here multiple rake are used, So load will be divided into all of rake plate.

7. Conclusion:

Cleaning the beach becomes simple, accurate and practical with the above impression, and it can be done in many places in the future, supporting the ecological environment for the next level. . Having a clean and healthy beach can save millions of people living in the sea who die or get poisoned by eating plastic. In this way, we ensure a healthy and environmentally friendly environment not only for ourselves, but also for marine creatures.Beach sand cleaner effectively removed various debris, debris and dirt from beach sand. Beach cleaning has successfully led to a reduction in pollution. The beach environment is clean and safety has been achieved. The amount of manual labor required for cleaning the beach has decreased, and the time required for cleaning the beach has also decreased. The beach sand cleaner is user-friendly and easy to use for everyone. The beach sand cleaner is cheap and affordable compared to other devices.

6. REFERENCES:

[1] Design and Fabrication of Beach Cleaning Vehicle (2023)1B. Sai Charan, 2K.Vijayawada Kumar, 3B. Nitish Kumar, 4B. Pavan, 5B. Vikas, 6D. Harsha Vardhan

[2] Design and Fabrication of Beach Sand Cleaning Machine (2020) Mepani Vrutan N1, Patel Himani N2, Vataliya Mohil B3, Prof. Sahu Rohit Kumar

[3] Manufacturing of Beach Cleaning Machine at University Malaysia Sabah(UMS)
Prototype Design and Analysis (2021) Nurmin Bolong1#, Ismail Saad2, Mohd Arman Madlan.

[4] Eco Beach Cleaner (2018) Amit Kuumar Yadav1, Animesh Singh2, M. A. Murtaza3.

[5] Design and fabrication of beach cleaning machine (2020) C Balasuthagar1, Dinesh Shanmugam1, K Vigneshwaran.

[6] Workshop Technology- Prof. Hazare and Prof. Choudhari.

[7] Production Technology - Prof. R. K. Jain.

[8] Workshop Technology - Prof. Bawa.