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Solar Powered Beach Cleaning Machine

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Abstract: *Beaches are one of the most attractive tourist places in the world, cleaning of beaches is neglected by most of the government bodies the main reason behind it takes up lots of resources and time. The housekeepers work manually by picking up garbage, it is difficult to clean the whole beach efficiently and in time. India has a 7517 km long coastline with nearly 70 famous beaches. we aim to design & fabricate a solar beach cleaning machine this machine is designed for simple economic work and it will be easy to maintain and use. This machine has been designed by looking at the current situation of our beaches which are loaded with waste material. The government of India has decided to clean beaches & for that many projects are done on various beaches. The design of the project on using push operated trolly connected with a solar panel. This machine is utilized to collect waste like bottles, plastic, paper, etc. The machine is designed in such a way that it is both cheap & easy to use.*

Keywords: renewable energy, Battery, Motor, Conveyor

I. INTRODUCTION

Beaches are major tourist attractions in India but are heavily polluted. Cleaning them is difficult because waste gets buried in sand due to strong coastal winds, making manual collection time-consuming and tiring for workers. The hot and humid climate further complicates the process. Existing beach cleaning machines are costly, require skilled operation, and often use fuel-based motors that cause pollution. To overcome these issues, a simple, low-cost, and eco-friendly beach cleaning machine has been developed. It uses human power or a solar-powered electric motor, making it easy to operate and maintain. The machine can efficiently remove waste, including plastic brought in by sea waves and tides, helping protect marine life and maintain environmental balance. This project aims to provide a sustainable solution that supports cleaner beaches and reduces human effort. By using renewable solar energy and locally sourced components, the machine ensures low operational cost and easy accessibility. It promotes environmental conservation while encouraging the adoption of green technology for coastal maintenance.

II. PROBLEM STATEMENT

Beaches are becoming increasingly polluted with plastic waste, food wrappers, fishing materials, and other debris left by visitors or brought in by tides. This pollution harms marine life, damages coastal ecosystems, and affects public health. Manual cleaning methods are slow, labour-intensive, and ineffective for large coastal areas. Existing beach-cleaning machines are heavy, expensive, fuel-powered, and unsuitable for sensitive beaches. They cause noise, emissions, and require skilled operators, making them impractical for many regions. Although beaches receive abundant sunlight suitable for solar power, the challenge is to design a lightweight, affordable, eco-friendly machine that can efficiently collect different types of waste on uneven sandy surfaces. Achieving high cleaning efficiency while maintaining good power output and durability remains a major engineering challenge.

III. LITERATURE REVIEW

Solar-powered beach cleaners are an eco-friendly alternative to fossil-fuel machines, reducing emissions and promoting sustainability. Studies focus on integrating photovoltaic panels for energy harvesting and optimizing battery storage. Prototypes feature autonomous/semi-autonomous designs with smart controls for efficient debris collection. Challenges include managing low-sunlight operation and navigating soft terrain. Research emphasizes modular arrays, cost-

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effective materials, and lifecycle assessments showing reduced carbon footprints. Existing models show potential but need scalability and efficiency improvements. Ultracapacitors are explored for quick energy bursts. Ongoing work aims for commercial viability and wider adoption.

Our Contribution**:**

1. Enhanced Energy Efficiency: Optimize solar panel placement.
2. Smart Debris Sorting: Implement AI-based waste segregation.
3. Adaptive Mobility: Develop terrain-aware wheels for beaches.

IV. METHODOLOGY

The methodology for developing the solar-powered beach cleaning machine involves five main stages. First, research and planning are carried out to study beach pollution, understand sand conditions, review existing cleaning machines, and define project requirements. Next, the design phase includes preparing sketches, selecting a suitable cleaning mechanism, and planning the power flow from the solar panel to the battery and motor. Component selection follows, where appropriate solar panels, batteries, DC motors, and mechanical parts are chosen based on efficiency and durability. In the fabrication stage, the chassis is built, and all components such as the solar panel, battery, motor, control unit, and cleaning mechanism are assembled into a working prototype. Finally, the machine is tested on different sand conditions to evaluate its cleaning efficiency, power consumption, stability, and user-friendliness, followed by necessary improvements.

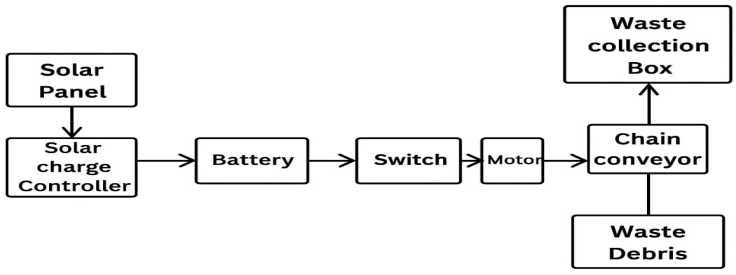
V. WORKING

The machine works by using solar panels to convert sunlight into electrical energy. This energy is stored in a battery, which powers a DC motor responsible for driving the cleaning mechanism. When the machine moves across the sand, a rake or scoop at the front lifts the top layer of sand and feeds it onto a conveyor or sieving system.As the sand passes through the vibrating or rotating sieve, waste materials such as plastic, bottles, wrappers, shells, and other debris are separated from the fine sand. The clean sand falls back onto the beach, while the collected waste is pushed into a storage hopper. An electronic control unit manages the conveyor speed, motor power, and overall operation. Solar energy continuously recharges the battery, allowing the machine to work for long hours with minimal maintenance. This process makes the machine eco-friendly, cost-effective, and efficient for cleaning beaches.

WORKING PRINCIPLE

Step 1: Solar panels capture sunlight and generate DC electricity.
Step 2: The charge controller regulates power and charges the battery safely.
Step 3: Stored battery power is supplied to the DC motor.
Step 4: The motor converts electrical energy into rotational motion.
Step 5:A conveyor/scoop mechanism collects waste from the sand.
Step 6: Trash is separated and stored in a collection bin.
Step 7: Clean sand is returned to the beach while the machine continues operation.

VI. BLOCK DIAGRAM



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COMPENTS USED

SolarPanel
Solar Charge Controller
Battery
Switch
Motor
Chain Conveyor
Waste Collection Box
Waste Debris

VII. COMPONENTS DESCRIPTION

Solar Panel

Solar Panel – 12V, 20W monocrystalline panel – converts solar energy into electrical energy. solar panel is the main source of energy for the system. It converts sunlight into electrical energy using photovoltaic (PV) The cells that generate direct current (DC) power. The panel works efficiently when exposed to maximum sunlight and provides a clean, renewable, and eco-friendly source of power. The amount of power produced depends on the intensity of sunlight and the surface area of the panel. It supplies energy to the rest of the system without any fuel or emissions. Solar panels are usually mounted at an angle to capture maximum sunlight during the day.

Solar Charge Controller

Solar Charge Controller 12V, 10A – regulates voltage and current from solar panel to batter. A solar charge controller is an essential component in a solar power system that regulates the voltage and current coming from the solar panels to the battery. Its main function is to prevent overcharging, over-discharging, and reverse current flow, ensuring the battery operates efficiently and lasts longer. There are two main types of solar charge controllers—PWM (Pulse Width Modulation) and MPPT (Maximum Power Point Tracking).

Battery

Rechargeable Battery – 12V, 7Ah lead-acid – stores energy from solar panel**.** A battery is a device used for storing and supplying electrical energy. It acts as a rechargeable and secondary cell, meaning it can be used multiple times after recharging. It is made up of one or more electrochemical cells, which convert chemical energy into electrical energy. Rechargeable batteries come in various shapes and sizes — from small button cells used in watches to large megawatt systems used in power networks. Different types of batteries are made using various combinations of electrode materials and electrolytes. One common example is the lead–acid battery, often used in vehicles.

Switch

A switch is an electrical device used to control the flow of current in a circuit. It works by opening or closing the electrical path, allowing or stopping the flow of electricity. In a solar-powered beach cleaning machine, switches are used to operate motors, pumps, and sensors safely. Common types include toggle, push-button, rocker, and limit switches. They help the operator start or stop different parts of the machine easily. Waterproof or dustproof switches are preferred for outdoor and wet environments. Switches can also act as safety controls to prevent overloading or short circuits. They are connected in series with the component they control.

Motor

DC Motor 12V, 300 RPM geared motor – used for driving cleaning conveyor. The mechanism utilizes a 12V DC motor, which plays a crucial role in rotating the shaft to achieve the required load and torque for the system. This motor is responsible for managing the entire conveyor mechanism. It operates at 337 RPM with a power rating of 250 watts, making it suitable for bearing the load of the conveyor. The motor delivers a constant torque of 8 Nm and has a stall torque of 40 Nm, ensuring efficient and reliable performance under varying load conditions.

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Chain Conveyor

Chain and Sprocket Mild steel – used to transmit motion from motor to conveyor 2 set. The conveyor mechanism consists of four universal bearings, two shafts, four chain sprockets, and two chains. A fork is attached to the chains, which rotates to collect waste from the beach. This setup ensures smooth operation and efficient waste collection. The shafts used in the mechanism are made of mild steel, providing the necessary strength and durability for the conveyor system.

Waste collection Box

Waste Collector Bin – metal container to collect and store solid waste. The waste collection box is a crucial component of the solar powered beach clearing machine, designed to store the debris and waste materials collected from the beach surface during the cleaning process. As the machine moves forward, the conveyor belt or rake mechanism gathers litter such as plastic bottles, wrappers, glass pieces, and other unwanted materials from the sand. These collected wastes are then transferred into the waste collection box, which serves as a temporary storage unit.

Waste debris

Waste debris refers to unwanted or discarded materials that accumulate on the beach surface due to human activities, ocean currents, or natural events. Common examples include plastic bottles, food wrappers, glass pieces, paper cups, polythene bags, fishing nets, cans, and wooden sticks. These materials are often non-biodegradable and remain in the environment for long periods, causing pollution and harming marine life.

VIII. ADVANTAGES

- **Eco-Friendly:** Runs on renewable solar energy, reducing carbon footprint and environmental impact. Promotes sustainable beach maintenance and conservation.
- **Cost-Effective:** Zero fuel costs, low maintenance, and reduced operational expenses. Minimizes waste and optimizes resource utilization.
- **Increased Mobility:** No cords or cables, easy to maneuver on beaches. Versatile and adaptable to different terrain and conditions.
- **Quiet Operation:** No noise pollution, preserving beach tranquility. Ideal for sensitive ecosystems and tourist areas.
- **Efficient Cleaning:** Effective removal of debris, trash, and microplastics. Maintains beach cleanliness and aesthetic appeal.
- **Low Operating Costs:** Minimal maintenance and no fuel costs. Reduces operational expenses and enhances sustainability.
- **Enhanced Safety:** No risk of fuel spills or electrical hazards. Ensures safe operation for users and beachgoers.

IX. LIMITATIONS

1. **Weather Dependent**: The machine works less efficiently during cloudy weather or at night.
2. **Low Power Output:** Limited solar energy reduces speed and cleaning capacity.
3. **High Initial Cost:** Solar panels and batteries make the machine expensive to build.
4. **Surface Limitations**: The machine struggles on wet, rocky, or uneven beach surfaces

X. CONCLUSION

The solar-powered beach cleaning machine offers an innovative and eco-friendly solution for maintaining clean and healthy coastlines. By using solar energy as its main power source, it reduces dependence on fossil fuels, lowers carbon emissions, and operates efficiently in sunny coastal areas. Its simple mechanism with a rechargeable battery and debris-collecting system effectively removes plastic waste, seaweed, and other contaminants from the sand, preventing pollution from entering the ocean. The backup battery ensures the machine works even in low-light conditions,

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improving its practicality for real use. Overall, this machine provides a cost-effective, sustainable method for beach maintenance, enhances environmental protection, supports tourism, and demonstrates how renewable energy can address major environmental challenges.

XI. FUTURE SCOPE

The future scope of the solar-powered beach cleaning machine includes adding smart features like GPS navigation, autonomous movement, and sensor-based monitoring to reduce human effort and improve accuracy. IoT-based tracking can help record the type and amount of waste collected for better environmental planning. Improvements in battery capacity, solar panel efficiency, and lightweight materials can enhance performance and durability, while adjustable cleaning mechanisms can make the machine effective on different beach conditions.

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