Design and Development of a Zero Emission Solar Integrated Road Cleaning System

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Abstract

This paper presents the design of a zero-emission solar integrated road cleaning system. The main objective of this system is to reduce pollution and manual effort in road cleaning. The system uses solar energy as a power source, which is stored in a battery and used to operate the vehicle and cleaning mechanism.

The setup consists of solar panel, battery, DC motor and cleaning brushes. The system is designed to collect dust and small waste particles from the road surface. Basic automation is also included to improve the working efficiency. The system is simple, cost-effective and suitable for small scale applications. The results show that it can be used as an alternative to conventional cleaning methods.

Index Terms: Solar Energy, Electric Vehicle, Road Cleaning, Zero Emission, Automation

1. INTRODUCTION

Road cleaning is an essential activity for maintaining cleanliness and hygiene in urban as well as rural areas. Clean roads help in improving public health, reducing dust pollution and maintaining a better environment. In most places, road cleaning is still carried out manually or by using conventional fuel-based machines, which require more labor and time [1]. Fuel-based machines also contribute to air pollution and increase operating cost [2].

With the increase in environmental issues and depletion of fossil fuels, there is a growing need for eco-friendly and energy efficient systems. Renewable energy sources such as solar energy play an important role in solving these problems. Solar energy is clean, renewable and easily available, making it suitable for various applications [3]. Many researchers have focused on the use of solar energy in electric vehicles and automation systems. Sharma et al. [4] studied the design of solar powered vehicles, while Patil et al. [5] worked on automated cleaning systems for public areas. The concept of electric vehicles is also gaining importance due to their zero emission and low maintenance advantages [6]. By combining solar energy with electric vehicles, it is possible to develop systems that are both energy efficient and environmentally friendly. In addition to this, the use of automation can further improve system performance and reduce human effort [7].

The main objective of this project is to design and develop a zero emission solar integrated road cleaning system. The proposed system uses solar panels to generate electricity, which is stored in a battery and used to drive the vehicle and cleaning mechanism. The cleaning system consists of brushes and collection units to remove dust and small waste particles from the road surface. Basic automation is included to improve efficiency and ease of operation. The developed system is simple, cost-effective and suitable for small scale applications such as streets, campuses and industrial areas.

2. METHODOLOGY

The methodology adopted for the development of the zero emission solar integrated road cleaning system is based on a systematic engineering approach. The complete process

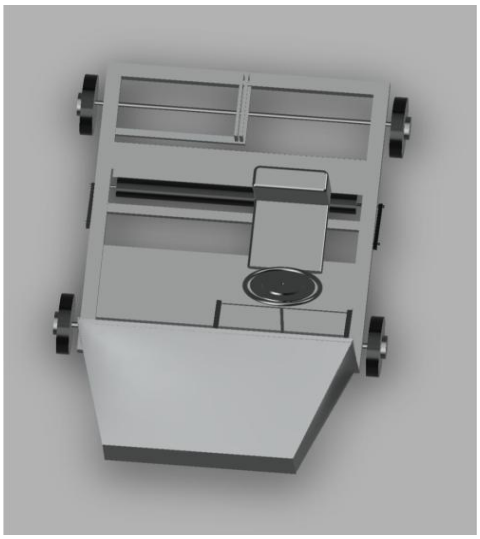
includes calculation, design, fabrication, assembly and testing of the system. This type of step-by-step approach is commonly used in the development of solar powered cleaning machines and electric vehicles [1].

A. System Calculations

The initial stage of the project involves calculation of power requirements for the system. the total load is calculated by considering dc motors used for vehicle movement and cleaning mechanism. Based on this, the capacity of the solar panel and battery is selected. Battery rating is calculated to ensure sufficient backup during low sunlight conditions. Proper calculations help in selecting suitable components and improving overall system efficiency [2].

B. System Design

After calculations, the system is designed as a compact and lightweight structure. The design includes proper placement of solar panel, battery, motors and cleaning unit. The solar panel is mounted on the top to capture maximum sunlight. The chassis is designed to support all components and provide stability during operation. In similar systems, proper weight distribution and compact design improve performance and mobility [3].



C. Fabrication Of Components

In this stage, the mechanical structure of the system is fabricated using suitable materials. The chassis is developed using lightweight metal to reduce overall weight. The DC motors are mounted on the frame and connected to the wheels. Cleaning brushes are fabricated and installed at the front side of the vehicle. The selection of materials and components is done based on strength, durability and cost.

D. Assembly of System

All fabricated components are assembled to form the complete system. Electrical connections are made between solar panel, battery and motors using proper wiring. The cleaning mechanism is integrated with the vehicle structure. Proper alignment of brushes and wheels is ensured for smooth operation. The assembly process is carried out carefully to avoid any mechanical or electrical faults.

E. Automation Implementation

Automation is implemented using sensors and control logic. The system is designed to control motor operation and improve efficiency. Sensors can be used for detecting obstacles and controlling the cleaning mechanism. This reduces manual effort and enhances system performance. Similar automation techniques are used in modern cleaning systems for better control and operation [4].

F. Testing and Performance Evaluation

After complete assembly, the system is tested under different operating conditions. The testing is carried out on different road surfaces to check cleaning performance. Parameters such as cleaning efficiency, power consumption and system stability are evaluated. The results are analyzed to verify the performance of **the** system and identify any improvements required.

G. Cost Analysis

The overall cost of the system is analyzed to ensure that it is economical and suitable for practical applications. The use of solar energy reduces fuel cost and operating expenses. The system is designed using simple and low-cost components, which makes it affordable and easy to maintain.

3. RESULTS AND DISCUSSION

The developed zero emission solar integrated road cleaning system was tested under different working conditions to evaluate its performance. The results are discussed based on battery discharge time, distance travelled and cleaning efficiency.

A. Battery Performance

The system uses a 12V battery for operation. During testing, it was observed that the battery provided continuous power supply to the system for approximately 1.5 to 2 hours under normal working conditions. The discharge time depends on load conditions such as motor usage and cleaning mechanism operation. It was observed that efficient energy utilization improves overall performance of the system [1].

B. Vehicle Movement Analysis

The vehicle is driven using a 48V, 750W DC motor. During testing, the vehicle was able to travel approximately 4 to 6 km on a single full charge under moderate load conditions. The speed of the vehicle was found to be stable and suitable for cleaning operations. The total weight of the vehicle is around 200 kg, which affects the power consumption and travel distance.

C. Cleaning Efficiency

The cleaning mechanism consisting of rotating brushes was able to effectively remove dust, small debris and dirt from the road surface. During testing, it was observed that the system performed efficiently on smooth and moderately rough surfaces. The cleaning efficiency depends on factors such as brush speed, surface condition and vehicle speed. The system showed satisfactory performance in maintaining cleanliness with minimal manual effort.Brushes was tested on different road surfaces. It was observed that the system was able to collect 70–80% of dust and small waste particles effectively. The efficiency depends on surface condition and type of waste. The system performs better on dry surfaces compared to wet surfaces.

D. Power Consumption

The power consumption of the system mainly depends on motor load and cleaning operation. It was observed that higher load conditions reduce battery backup time. The use of solar energy helps in partially charging the battery during operation, which improves overall efficiency [2].

E. Overall Performance

The overall performance of the system was found to be satisfactory for small scale applications. The system operates smoothly with low noise and zero emission. It reduces manual effort and provides an eco-friendly solution for road cleaning. The results indicate that the system can be effectively used in areas such as campuses, streets and industrial zones.

4. CONCLUSION

The zero emission solar integrated road cleaning system is successfully designed and developed. The system uses solar energy, which reduces pollution and fuel consumption. The integration of electric vehicle and cleaning mechanism provides an effective solution for road cleaning.

The results show that the system performs satisfactorily in terms of battery backup, distance travelled and cleaning efficiency. It is simple, cost-effective and suitable for small scale applications. In future, the system can be improved by using advanced components to increase efficiency and performance.

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