

MODELING AND FABRICATION OF A SEMI-AUTOMATED ROAD SWEEPING MACHINE FOR EFFICIENT ROAD CLEANING

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ABSTRACT

This project focuses on the modelling, design, and fabrication of a semi-automated road sweeping machine aimed at improving road cleanliness while reducing manual labour and health risks. Conventional road cleaning methods are labour-intensive, time-consuming, and expose workers to harmful dust, while fully automated systems are often complex and less accessible for small-scale use. To address this gap, a semi-automated solution was developed using SolidWorks for accurate design and assembly. The machine operates on a rotating brush mechanism powered by an electric motor, which effectively collects dust and debris into a storage container. The fabricated prototype was tested for ease of operation, demonstrating improved cleaning effectiveness compared to manual methods. The modelling emphasizes portability, simplicity, and user-friendly operation, making it suitable for small roads, campuses, and public areas. The project highlights the potential of a practical and efficient road cleaning system with opportunities for further enhancement and automation.

KEYWORDS

Semi-Automated Road Sweeper, Road Cleaning Machine, Rotary Brush Mechanism, Fabrication, SolidWorks, Waste Collection System, Low-Cost Automation, Cleaning Efficiency

1.INTRODUCTION

Maintaining clean and dust-free roads is essential for ensuring environmental hygiene, protecting public health, and enhancing the aesthetic appearance of urban and semi-urban areas. Rapid urbanization, population growth, and increased vehicular movement have significantly contributed to the accumulation of dust, debris, and solid waste on road surfaces. Traditional road cleaning methods, which mainly rely on manual labor, are time-consuming, labor-intensive, and often expose workers to harmful dust particles and pollutants, leading to health risks and reduced efficiency.

To overcome the limitations of manual sweeping, various road cleaning methods have been developed, including mechanical, motorized, and automated sweeping systems. While manual and push-type mechanical sweepers are cost-effective and simple, they require considerable physical effort and provide limited efficiency.

On the other hand, fully automated and vacuum-based sweeping machines offer high cleaning performance but involve high initial costs, complex maintenance, and the need for skilled operation, making them less suitable for small-scale or semi-urban applications.



Fig: 1.1 Manual Sweeping

Considering these challenges, there is a need for an intermediate solution that balances efficiency, affordability, and ease of operation. The semi-automated road sweeping machine is proposed as a practical alternative that reduces human effort while maintaining effective cleaning performance. This system incorporates a rotating brush mechanism powered by an electric motor, which efficiently sweeps and collects dust and debris into a collection container, thereby improving hygiene and operational convenience.

The present project focuses on the modeling and fabrication of this semi-automated road sweeper using SolidWorks for accurate 3D modeling and assembly validation. The developed machine is portable, user-friendly, and operable by a single individual. The overall aim is to enhance cleaning efficiency, reduce time consumption, and provide a practical solution suitable for small roads, campuses, and public areas, with potential for further improvements in automation and performance.

2. LITERATURE REVIEW

Road cleaning systems have been widely studied to improve efficiency, reduce labor dependency, and enhance environmental sustainability. Various approaches such as mechanical, solar-powered, electric, and automated sweeping machines have been developed by researchers in recent years.

Khan et al. [1] developed a smart solar-powered street sweeping machine aimed at reducing energy consumption and promoting eco-friendly operation. Their system utilized renewable energy sources, making it sustainable, but its efficiency depended on weather conditions. Aderinmoye and Adebisin [2] proposed a mechanically operated street sweeper that improved cleaning performance while maintaining simplicity and ease of fabrication. However, the system required continuous human effort for operation.

Jamil et al. [3] introduced an electric remote-controlled road sweeper vehicle that reduced human intervention and improved operational safety. While effective, the inclusion of remote-control systems increased system complexity and cost. Similarly, Vanalkar et al. [4] developed an eco-friendly road sweeping machine focusing on minimizing environmental impact and improving cleaning efficiency using innovative mechanisms.

Bhalerao et al. [5] worked on enhancing existing street sweeper machines by improving brush mechanisms and collection efficiency. Their modifications showed better performance but still required manual handling. Ram et al. [6] designed a mechanically operated street sweeper that was simple and effective for small-scale applications, but it lacked automation features.

Kimuli [7] presented a design and simulation-based approach for a road sweeping machine, emphasizing modeling and performance analysis. The study provided valuable insights into system efficiency but lacked practical implementation. Enad [8] focused on robotic street sweeper simulation, demonstrating high efficiency through automation; however, the system required advanced control and programming, making it less accessible for common use.

Farella et al. [9] developed an energy-efficient road sweeper integrated with deep vision technology for intelligent cleaning. Although highly efficient, such systems involve complex technologies and higher implementation challenges. Meshram and Mehta [10] introduced a tricycle-operated street cleaning machine that was economical and easy to operate but limited in cleaning capacity and efficiency.

From the above studies, it is evident that while automated and robotic systems provide high efficiency, they increase complexity and cost. On the other hand, simple mechanical systems are economical but require significant manual effort. Therefore, there is a need for a semi-automated road sweeping system that combines efficiency, simplicity, and ease of operation. The present work aims to address this gap by developing a practical and effective semi-automated road sweeping machine.

3. METHODOLOGY

The methodology of the proposed semi-automated road sweeping machine involves system planning, component selection, and working mechanism development to achieve efficient cleaning performance with reduced manual effort. The system is designed to be simple, portable, and easy to operate, making it suitable for small-scale applications such as campuses, streets, and public areas.

The overall system consists of key components including a structural frame, rotating brush, electric motor, shaft, bearings, wheels, and a dust collection unit. Each component plays a vital role in ensuring proper functioning of the machine. The frame provides structural support and holds all components in position, while the wheels enable smooth movement of the machine across road surfaces.

The working principle of the machine is based on a motor-driven rotating brush mechanism. When the motor is powered, it rotates the brush at a suitable speed. As the machine is pushed forward manually, the rotating brush comes into contact with the ground surface and sweeps dust, dry leaves, and small debris. The collected waste is then directed into a storage container placed behind the brush. This mechanism ensures continuous cleaning with minimal human effort.

Proper alignment of the shaft and bearings is maintained to reduce friction and ensure smooth rotation of the brush. The selection of brush material is also important, as it should be durable and capable of effectively removing dust without damaging the road surface. Nylon bristles are commonly used due to their flexibility and wear resistance.

The methodology also includes testing and evaluation of the machine under different working conditions. The machine is tested on various surfaces to analyze its cleaning efficiency, ease of operation, and overall performance. The results obtained help in identifying limitations and potential areas for improvement.

4. MODELLING AND FABRICATION

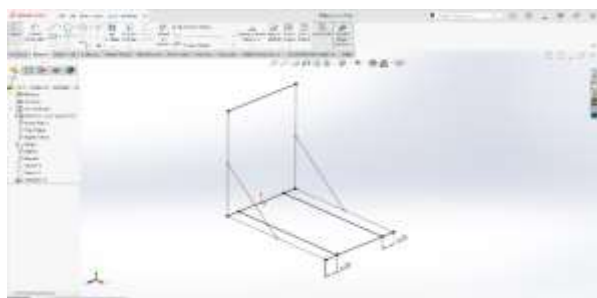
The modelling and fabrication of the semi-automated road sweeping machine are carried out to develop a functional prototype that meets the required performance criteria. The modeling process is performed using SolidWorks software, which enables accurate 2D and 3D representation of the components and assembly. This helps in visualizing the complete system and identifying any design-related issues before fabrication.

The fabrication process begins with the selection of suitable materials for each component. Mild steel is used for the frame due to its high strength, durability, and ease of welding. The rotating brush is made using a cylindrical shaft fitted with nylon bristles to ensure effective sweeping action. Other components such as bearings, wheels, and fasteners are selected based on availability and compatibility.

The manufacturing process involves several steps, including cutting, drilling, welding, grinding, and assembly. Initially, the frame is constructed by cutting and welding mild steel sections according to the required dimensions. The shaft is then mounted on the frame using bearings to allow smooth rotation. The brush is attached to the shaft, and the motor is connected to provide rotational motion through a suitable power transmission mechanism.

After assembling all components, the machine undergoes finishing processes such as painting and surface treatment to improve durability and appearance. The final assembled machine is then tested to ensure proper alignment, smooth operation, and effective cleaning performance. Any defects observed during testing are corrected to enhance the overall functionality of the system.

The modelling and fabrication process ensures that the developed machine is robust, efficient, and capable of performing its intended function. The use of standard materials and simple manufacturing techniques makes the system easy to replicate and maintain, thereby increasing its practical applicability.



5. RESULTS AND DISCUSSION

The performance of the semi-automated road sweeping machine was evaluated based on parameters such as cleaning efficiency, ease of operation, time consumption, and overall effectiveness in removing different types

of waste materials. The testing was carried out on various surfaces including paved roads, sidewalks, and campus pathways to analyze the adaptability of the machine under different working conditions.

The results indicate that the machine is capable of effectively removing dry dust, sand particles, paper waste, and small debris from the surface. The rotating brush mechanism plays a crucial role in sweeping and directing the waste into the collection container. Compared to traditional manual sweeping methods, the machine significantly reduces cleaning time and physical effort required by the operator.

Another important observation is the ease of operation of the machine. Since the system is semi-automated, it does not require specialized skills or training. The operator can easily control the movement of the machine while the cleaning mechanism operates automatically. This makes the system suitable for use in small-scale applications such as educational institutions, residential areas, and public spaces.

However, certain limitations were observed during testing. The machine is less effective in handling wet waste and sticky materials, as they tend to adhere to the surface and are not easily collected by the brush mechanism. Additionally, very fine dust particles may not be completely captured due to the absence of a suction or vacuum system. These limitations suggest that further improvements can be made to enhance the overall performance of the system.

Despite these limitations, the machine demonstrates a significant improvement over manual sweeping methods in terms of efficiency, consistency, and user convenience. The results confirm that the proposed semi-automated road sweeping machine is a practical and effective solution for maintaining cleanliness in small-scale environments.

6. CONCLUSION

In this study, a semi-automated road sweeping machine was successfully developed with the aim of improving road cleanliness while reducing manual effort and health risks. The system combines mechanical simplicity with effective cleaning performance, making it a suitable alternative to both manual and fully automated sweeping methods.

The machine operates on a rotating brush mechanism powered by an electric motor, which efficiently collects dust and debris into a storage container. The developed prototype demonstrated improved cleaning efficiency, reduced time consumption, and ease of operation when compared to conventional manual sweeping techniques. The system is portable, user-friendly, and suitable for various applications such as small roads, campuses, and public areas.

The study also identified certain limitations, particularly in handling wet waste and very fine dust particles. These challenges highlight the need for further enhancements to improve the overall effectiveness of the system. Future developments may include the integration of a vacuum suction mechanism, water spraying system for dust suppression, and partial or full automation to minimize human intervention.

Overall, the proposed semi-automated road sweeping machine provides a simple, efficient, and practical solution for maintaining cleanliness in small-scale environments. With further improvements and technological integration, the system has the potential to be widely adopted for sustainable and effective road cleaning applications.

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