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Hydraulic Trolley System Design for Electric Vehicle Lifting Platforms

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ABSTRACT

This project aims to design and develop an electric vehicle (EV) loader tailored for industrial and commercial loading applications. As industries shift towards eco-friendly practices, there is an increasing demand for sustainable equipment that can handle heavy loads efficiently while reducing environmental impact. This electric loader is engineered to provide high torque and power output for lifting and transporting materials within warehouses, construction sites, and distribution centers. By incorporating advanced battery technology and energy-efficient motors, the loader ensures extended operational time and minimal emissions. The project encompasses the design, simulation, and testing of the EV loader prototype, focusing on load capacity, safety, energy management, and ease of operation to support sustainable, high performance material handling solutions. The development of an electric vehicle (EV) loader equipped with a hydraulic lift is an innovative approach to enhancing the efficiency, sustainability, and adaptability of loading and material handling operations. This design integrates an electric-powered loader with a hydraulic lifting system, providing an eco-friendly alternative. The electric vehicle loader is powered by a battery pack, reducing greenhouse gas emissions and reliance on fossil fuels, which aligns with global sustainability goals. The hydraulic lift system allows for precise and robust handling of materials, with the capability to lift heavy loads smoothly and safely. The primary features include a rechargeable battery system, which provides a clean and silent operational environment, and advanced hydraulics for load stability and control. This setup also incorporates energy saving measures, such as regenerative brake which returns energy to the battery during load descent. The EV loader with hydraulic lift offers applications in diverse fields, including construction, warehousing, and manufacturing.

1. Introduction

The rapid advancement of technology has significantly influenced various sectors, including agriculture and industry. Traditional methods in these sectors often rely heavily on fuel powered vehicles and machinery, which present several challenges such as high operating costs, environmental pollution and frequent maintenance issues. As the demand for eco-friendly solutions grows, electric vehicles (EVs) have emerged as a viable alternative to conventional fuel powered systems. In agriculture, the use of vehicles is crucial for transporting crops, fertilizers and tools. However, conventional tractors and loaders powered by internal combustion engines (ICE) consume substantial amounts of fuel, contributing to rising operational expenses. Additionally, these vehicles emit harmful gases such as carbon dioxide (CO_2), nitrogen oxides (NOx) and particulate matter, posing environmental risks. Similarly, industrial applications rely heavily on material handling equipment such as forklifts, carts and utility vehicles. These machines are often required to operate indoors, where emissions can degrade air quality and pose health risks to workers. Moreover, industrial vehicles often face the challenge of maneuvering within confined spaces, requiring efficient and compact designs. Electric vehicles offer several advantages in these sectors: ¬ Reduced Operating Costs: EVs eliminate the need for costly fuels, relying instead on electricity, which is generally more affordable. ¬ Eco-friendly Solution: With zero tailpipe emissions, EVs significantly reduce the environmental impact compared to ICE vehicles. ¬ Energy Efficiency: Electric motors are highly efficient, converting a greater percentage of energy into useful work. ¬ Lower Maintenance Needs: EVs have fewer moving parts, reducing the risk of mechanical failures and minimizing maintenance costs.

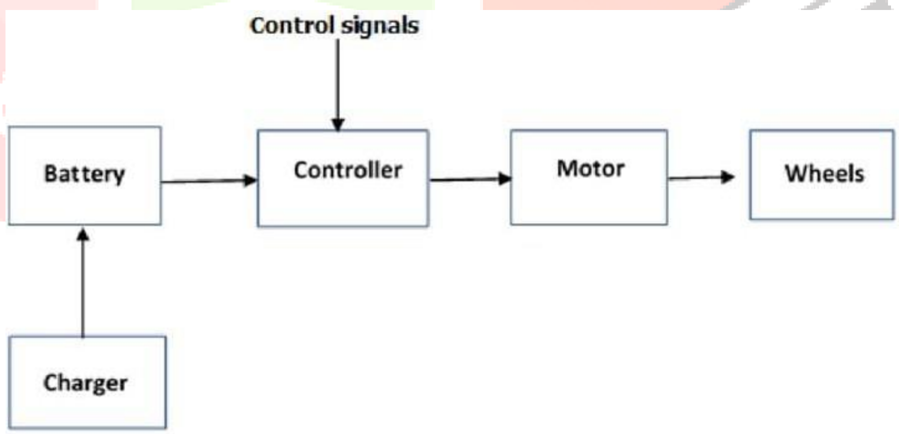

Fig 1.1 : Fabrication of Electric vehicle

2. Literature Survey

Agriculture relies heavily on vehicles for activities such as soil preparation, planting, irrigation and harvesting. Recent research highlights the potential of electric vehicles to improve efficiency while reducing environmental impact. Electric Vehicles in Industrial Applications In industrial sectors, material handling equipment such as forklifts, carts and loaders plays a crucial role in warehouse operations, factory logistics and product transportation. Researchers have investigated the integration of electric power systems to enhance performance and reduce operational costs. Powertrain and Battery Technologies The powertrain and battery technology are the most critical components of an electric vehicle (EV), directly affecting performance, efficiency and durability. The effectiveness of electric vehicles heavily depends on efficient powertrain systems and battery technologies. Researchers have explored various battery types, motor configurations and energy management techniques to optimize performance. The integration of electric powertrain components reduces emissions, noise pollution and operating costs, making the vehicle environmentally friendly and economically viable. Moreover, the system allows for regenerative braking, which enhances energy efficiency by converting kinetic energy back into stored battery power during braking. Electric Motor: Converts electrical energy into mechanical energy (torque). This combination improved structural stability while reducing vehicle weight, enhancing energy efficiency. • A. Gupta et al. (2021) introduced a modular chassis concept that allowed easy customization based on load capacity and terrain conditions. The modular design improved adaptability for both agricultural and industrial use.

- Vibration Dampening Systems: Research indicates that integrating shock absorbers and suspension systems enhances vehicle stability, especially when operating on rough agricultural terrain. A well- designed chassis ensures the vehicle's ability to handle heavy loads while maintaining stability and durability.Performance and Cost analysis of an Electric vehicle Renewable Energy Integration in Electric vehicles The integration of renewable energy sources such as solar panels in electric vehicles has gained attention as a method to improve operational efficiency and reduce dependence on grid charging. Key Findings: • S. Khan et al. (2020) developed a solar-powered electric vehicle designed for agricultural applications. The study demonstrated that solar charging extended operational hours, especially in rural areas with unreliable electricity supply. • A. Das et al. (2022) explored the potential of hybrid charging systems that combine grid power with solar energy to maximize charging flexibility and improve cost efficiency. Renewable energy integration offers a sustainable solution for extending battery life.

3. Methodology & Materials

The 3D modeling of the Electric Vehicle Loader body frame was carried out using SolidWorks software, a powerful parametric CAD tool widely used in the mechanical design industry. SolidWorks was chosen for its intuitive interface and robust feature set, which allowed for precise modeling and assembly of the structural components. The aim was to design a realistic, functional representation of the body frame to validate the design before physical fabrication. The body frame design was primarily created using the Extrude and Extrude Cut tools in SolidWorks. The Extrude Boss/Base feature was utilized to convert 2D sketches into 3D solid parts, forming the structural members such as beams, supports and panels. This method ensured uniform thickness and dimensional accuracy throughout the frame. The frame structure includes angular and vertical supports, providing necessary rigidity and strength for the electric loader application.

Figure 3.1 Motor and Battery used in the vehicle

The development of the hydraulic lift and trolley system for an electric vehicle (EV) involved a systematic approach that began with the identification of the operational requirements. Initial design specifications were established based on the vehicle's weight, intended lifting height, safety factors, and maneuverability. CAD modeling software was used to design the lift structure and trolley frame, ensuring proper load distribution and structural integrity. Finite Element Analysis (FEA) was conducted to validate the design under simulated load conditions. Based on the analysis, modifications were incorporated into the prototype design before moving to the fabrication stage. The fabrication process utilized mild steel (MS) for the trolley frame and lift arms due to its high strength, ease of machining, and cost-effectiveness. The hydraulic system was composed of a manual hydraulic jack, pressure lines, and valves capable of lifting loads up to 1.5 tons. Welding, cutting, and drilling were carried out using precision tools to ensure dimensional accuracy and robustness of the structure. All joints were reinforced using gussets and support plates to prevent structural failure during operation.

The trolley platform was mounted on four castor wheels with ball bearings to provide smooth mobility in all directions. The wheels were selected based on load-bearing capacity and terrain compatibility. Rubber padding was added to the lift platform to reduce slippage and prevent damage to the EV chassis during lifting. Additionally, the hydraulic system was integrated with a locking mechanism to maintain stability during maintenance operations. The entire system was tested under various load conditions to ensure repeatability and reliability of lifting performance.

Finally, safety and performance evaluations were conducted to verify compliance with industrial standards. Parameters such as lift time, pressure distribution, and structural deformation were measured and compared against expected values. The prototype demonstrated effective performance with minimal deviation, confirming its suitability for garage-based EV maintenance. The methodology adopted emphasizes a balance of simplicity, durability, and functionality, making the system a viable solution for both commercial and educational applications.

Estimation of Cost Analysis

Cost analysis of an EV includes the initial manufacturing costs, operating costs and maintenance expenses. Below is a breakdown of the key cost factors involved in an Electric vehicle,

Major Components & Costs:

Component	**Estimated cost (INR)**
Hydraulic kit	15000/-
Motor	10000/-
Controller	8000/-
Suspension Spring	16000/-
Differential	12000/-
Steering & Front axle	10000/-
Chassis Frame(Channel pipes&Aluminium sheet)	18000/-
Harness kit	4000/-
Speedometer & Throttle	4500/-
Painting	6000/-
Lights & Indicators	1900/-
DC to DC Converter	1300/-
Horn	1300/-
Seat & Top	4000/-
Tyers	8000 /-
Total Fabrication cost	1,20,000/-

4. Results and Discussions

The fabrication of an electric vehicle (EV) for agricultural and industrial applications was a successful endeavor, demonstrating the potential of sustainable, cost-effective and energy- efficient transportation for various industries. The project aimed to provide an alternative to traditional fuel- powered vehicles, reducing dependency on fossil fuels while ensuring operational efficiency and economic viability. The designed EV met its functional objectives by showcasing reliable performance, an adequate load-carrying capacity, and efficient power consumption. It was able to navigate agricultural terrains such as muddy fields, rocky paths, and inclines, as well as operate efficiently on industrial floors for material handling. The vehicle's battery-powered system significantly lowered fuel costs and maintenance expenses, making it an attractive solution for small and large-scale applications.

Furthermore, the project contributed to environmental sustainability by reducing carbon emissions, noise pollution, and energy wastage. Compared to conventional diesel or petrol- powered vehicles, the EV demonstrated lower operational costs and a smaller carbon footprint, aligning with global efforts to transition to greener energy solutions. From an economic perspective, the project highlighted that with the right battery technology, optimized design and efficient energy management, an electric vehicle can be cost-effective and commercially viable for agricultural and industrial applications. The break-even analysis showed that over time, the savings on fuel and maintenance costs could offset the initial investment, making it a financially sustainable solution.

Fig 4.1 Final Image of Electric vehicle

5. Conclusion

The Electric Vehicle with Hydraulic Lift project successfully demonstrates a sustainable and efficient solution for material handling and local transportation. By combining an electric drivetrain with a compact hydraulic lifting system, the vehicle offers both mobility and load- lifting capabilities in a single platform. The project highlights the potential of electric vehicles in reducing environmental impact while maintaining functionality for practical tasks. The successful testing of speed, load capacity, battery performance, and lifting operations confirms the reliability of the design. This innovative approach can be a valuable alternative to traditional fuel-powered loaders, especially in small-scale industries, farms, and warehouses. The results indicate that with further refinement and scaling, such vehicles can contribute significantly to the shift towards eco- friendly and cost-effective transportation and handling systems.

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