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Development of a Compact and Portable EV for Urban Mobility

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ABSTRACT

This project focuses on a low-cost, portable electric bicycle (EV bicycle) designed to offer urban and semi-urban areas an affordable and eco-friendly mode of transportation. Priced at an estimated ₹38,000, this EV bicycle features a sturdy frame, PMDC motor, lithium-ion battery, throttle control, basic suspension system, and simple charging mechanism. It serves as a lightweight, foldable, battery-powered option for short-distance travel and daily commuting, addressing rising fuel prices, increasing traffic congestion, and environmental issues. The development process includes conceptual design, component selection, prototype construction, and testing. The bicycle's portability is enhanced by its foldable frame and compact design. The project also explores solar assisted charging and modular feature improvements while focusing on energy efficiency, weight reduction, and rider safety. This electric bicycle aims to improve last-mile connectivity for students, employees, and small business owners, reduce reliance on fossil fuels, lower carbon emissions, and provide a sustainable transportation alternative. The project demonstrates how innovative engineering can support eco-friendly urban mobility.

Keywords: Lightweight, Reduced fuel dependence, Lower carbon emissions, User safety.

INTRODUCTION

Rising fuel prices, increased traffic, and growing environmental concerns have driven up demand for affordable, compact, and eco-friendly transportation. Electric vehicles (EVs) are becoming a viable alternative to traditional fuel-powered vehicles because they have zero emissions and low operating costs. However, limited parking in cities and high initial costs hinder their widespread adoption. A low-cost folding electric vehicle concept has been proposed to address these challenges. Thanks to its lightweight, energy-efficient, and foldable design, this vehicle is well suited for crowded urban environments. It enhances mobility by being easy to store in small spaces such as office parking lots, small garages, and balconies. This design, which emphasizes user comfort, cost effectiveness, and sustainability, is appropriate for short-distance urban transport. The vehicle employs efficient electric propulsion systems, simple mechanical designs, and locally sourced materials to reduce manufacturing costs. By promoting clean energy use and reducing carbon emissions, it also benefits the environment. As urbanization and industrialization continue to grow, these foldable electric vehicles provide a practical solution to modern transportation challenges. They offer a space-saving, affordable, and environmentally friendly option for personal mobility. This concept aims to find a balance between sustainability, efficiency, and convenience for future urban transportation networks.

LIERATURE REVIEW

Sumit Kumar et al. (2023) used CAD modelling and FEA to develop a lightweight foldable e-bike with a BLDC motor and Li-ion battery. The prototype achieved a range of 30 km and a top speed of 25 km/h, enhancing portability by 40%. They suggested using regenerative braking and smart system integration to boost efficiency [1]. Subrahmanyam V. et al. (2025) examined key design elements for efficient e-bikes, comparing lithium-ion batteries with hub and mid-drive motors. Their study found that mid-drive motors with intelligent control systems and regenerative braking improve performance and efficiency. For sustainable urban transport, they recommended combining solar charging, IoT, and real-time monitoring [2]. According to Avy R. Patel et al. (2021), mild steel offers strength while aluminium improves portability in foldable two-wheeler designs. They emphasized cost reduction and real-time structural testing to enhance market viability, suggesting 250–500 W BLDC motors for urban applications [3]. An anonymous study explored advanced folding mechanisms for small e-bikes made of lightweight steel frames, enhancing cost-effectiveness, stability, and efficiency. Simulation results indicated optimal hinge placement enhances rider safety and mobility, making it suitable for future low cost e-bike designs [4]. Avy R. Patel et al. (2021) analysed the affordability and durability

of steel and aluminium for foldable e-two-wheelers. They highlighted the importance of properly aligning folding joints and recommended stronger, lighter materials for mass production [5].

METHODOLOGY

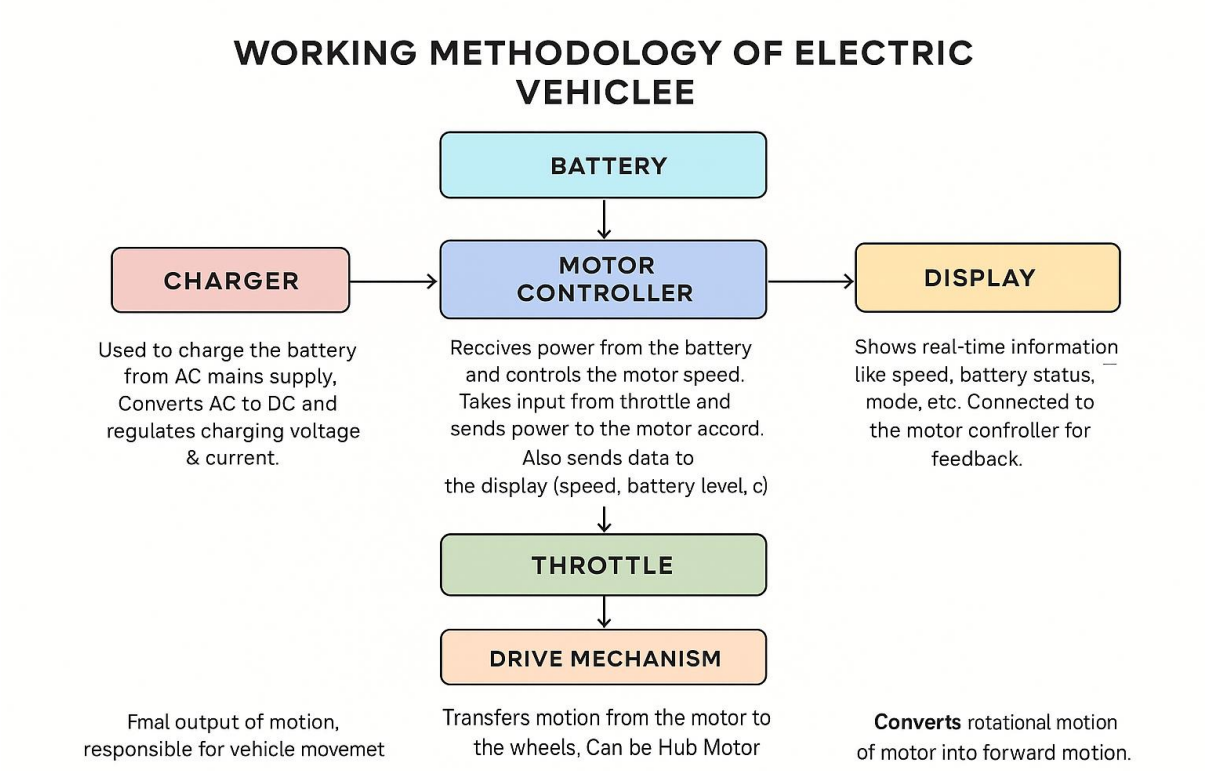

Fig 1: Working of an EV

Working Methodology of an Electric Vehicle

The Electric vehicles (EVs) convert electrical energy from the battery into mechanical energy to power the wheels. The system consists of interconnected parts including the charger, battery, motor controller, throttle, drive mechanism, wheels, and display system. Each component plays a unique role in ensuring the vehicle operates smoothly and efficiently.

Charger

The charger supplies electrical energy to the vehicle's battery. When connected to a power source, it converts alternating current (AC) from the grid into direct current (DC) to charge the battery pack. Depending on the charger type, it may be an external off-board fast charger or an on-board charger installed within the vehicle. The battery management system (BMS) and charger communicate to regulate the charging rate, prevent overcharging, and ensure battery safety.

Battery

The battery is the main energy storage element in the electric vehicle. It stores electrical energy in chemical form and provides the DC power necessary to operate the motor and other electrical components. Most modern EVs use lithium-ion batteries due to their long lifespan, high energy density, and efficiency. The BMS monitors temperature, state of charge (SOC), and individual cell voltages to maintain battery health, ensure safety, and optimize performance during charging and discharging.

Motor Controller

The motor controller acts as the brain of the electric drive system. It converts the DC power received from the battery into AC power for AC motors such as BLDC, PMSM, or induction motors. The controller uses the throttle signals to manage the motor's speed and torque. It employs pulse-width modulation (PWM) through power electronic switches like MOSFETs or IGBTs to control the power supplied to the motor.

Throttle

The throttle, or accelerator pedal, is the driver's input device that controls how much power the motor uses. When the driver presses the accelerator, the controller receives an electrical signal corresponding to the desired speed or torque. The controller adjusts the motor output accordingly. Modern EVs utilize an electrical "drive-by wire" system with sensors, instead of mechanical connections, to provide precise acceleration control.

Overall Working

In summary, the charger powers the battery, which initiates the operation of an electric vehicle. The motor controller takes the stored electrical energy and converts it into a regulated AC supply for the motor. The motor generates the necessary torque to turn the drive mechanism and move the wheels based on input from the driver's throttle. The controller uses sensor feedback to adjust performance and convey data to the display unit. EVs are generally more economical and environmentally friendly than conventional vehicles, thanks to regenerative technology that captures energy during braking and redirects it to the battery.

CONCLUSION

The project "Development of a Compact and Portable EV for Urban Mobility" effectively addresses current urban transportation challenges by combining affordability, sustainability, and innovation. This folding e-bike provides a practical and eco-friendly solution for short-distance commuting in light of increased traffic congestion, pollution, and fuel prices. Priced at around ₹38,000, it features a hub motor, throttle control, lithium-ion battery, and lightweight frame for a comfortable and smooth ride. Its collapsible design enhances portability for city commuters, office workers, and students. Performance evaluation demonstrated good speed, stability, and range for urban travel. Although the current version meets its objectives, future improvements such as regenerative braking, IoT-based monitoring, and higher battery capacity can further enhance performance. Overall, this project illustrates how affordable, locally made EVs can promote sustainable mobility, support "Make in India" initiatives, and contribute to cleaner, smarter cities. The integration of the hub motor and battery highlights the project's low maintenance, easy operation, and efficient energy use. It reduces carbon emissions and promotes sustainable energy mobility, with potential future models including solar-assisted charging. The design process incorporated CAD modelling, simulation, and prototype testing to ensure efficiency, strength, and safety.

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