

Retrofitting of Conventional SI Scooter into an Electric Drive System

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Abstract -The increasing demand for sustainable transportation and the need to reduce greenhouse gas emissions have encouraged the development of electric mobility solutions. This research presents the retrofitting of a conventional Spark Ignition (SI) scooter into an electric drive system by replacing the internal combustion engine with a hub motor, lithium-ion battery pack, motor controller, Battery Management System (BMS), and associated electrical components. The existing chassis is retained with necessary structural modifications, including battery mounting and swing-arm design, to accommodate the electric powertrain. Computer-Aided Design (CAD) is used to validate the modified structure before fabrication and assembly. The converted scooter is evaluated based on performance parameters such as speed, range, power consumption, efficiency, and operating cost. The study demonstrates that retrofitting is a technically feasible and cost-effective alternative to purchasing a new electric scooter. It extends the useful life of existing vehicles while reducing fuel consumption, maintenance costs, and environmental pollution. The proposed retrofit approach supports sustainable transportation and provides an economical solution for the transition from conventional fuel-powered two-wheelers to electric vehicles.

Index Terms - Electric Vehicle (EV), Spark Ignition (SI) Scooter, Retrofitting, Electric Drive System, Hub Motor, Lithium-ion Battery, Battery Management System (BMS), Motor Controller, Computer-Aided Design (CAD), Sustainable Transportation, Energy Efficiency, Green Mobility.

I. INTRODUCTION

The rapid depletion of fossil fuel reserves, increasing fuel prices, and growing environmental concerns have accelerated the global transition toward sustainable transportation systems. Conventional Spark Ignition (SI) engine scooters are widely used due to their affordability and convenience; however, they contribute significantly to air pollution, greenhouse gas emissions, and noise pollution. The transportation sector is one of the major contributors to carbon dioxide (CO₂) emissions, making the adoption of cleaner mobility solutions an important step toward achieving environmental sustainability.

Electric vehicles (EVs) have emerged as an effective alternative because they offer zero tailpipe emissions, lower operating costs, reduced maintenance requirements, and improved energy efficiency. Despite these advantages, the

high initial purchase cost of new electric scooters limits their widespread adoption, particularly in developing countries. Retrofitting existing conventional scooters into electric-powered vehicles provides a practical and economical solution by extending the service life of existing vehicles while reducing environmental impact.

Retrofitting involves replacing the internal combustion engine and associated components, such as the fuel tank, exhaust system, carburetor, and transmission-related parts, with an electric propulsion system consisting of a hub motor, lithium-ion battery pack, motor controller, battery management system (BMS), charger, throttle, and associated electrical wiring. This conversion preserves the existing chassis and structural components of the scooter while transforming it into a clean and efficient electric vehicle.

The present research focuses on the retrofitting of a conventional SI scooter into an electric drive system using a hub motor. The study includes the selection and integration of electric drive components, structural modifications such as swing-arm redesign and battery mounting, Computer-Aided Design (CAD) modeling, fabrication, assembly, and performance evaluation. Parameters including vehicle speed, range, power consumption, battery efficiency, load-carrying capability, and operating cost are analyzed to assess the feasibility and effectiveness of the converted vehicle.

The objective of this research is to develop a cost-effective, reliable, and environmentally friendly

electric scooter by utilizing existing vehicle infrastructure. The proposed retrofit system aims to reduce dependence on fossil fuels, lower vehicle operating costs, minimize carbon emissions, and promote sustainable transportation without requiring the manufacture of a completely new vehicle. The findings of this study are expected to provide valuable insights into the technical, economic, and environmental feasibility of retrofitting conventional two-wheelers into electric

II. OBJECTIVES OF DESIGN

1. To design a reliable electric drive system for converting a conventional SI scooter into an electric scooter.
2. To replace the internal combustion engine with a suitable hub motor and integrate it with the existing chassis.
3. To design and fabricate a battery mounting structure that provides adequate strength, safety, and weight distribution.
4. To modify the swing arm and other supporting components, where necessary, to accommodate the hub

motor while maintaining structural integrity.

5. To develop a CAD model of the modified scooter and validate the design before fabrication.

6. To ensure proper integration of the lithium-ion battery, motor controller, Battery Management System (BMS), charger, and electrical wiring.

7. To optimize the vehicle for improved energy efficiency, stability, and rider safety.

8. To minimize structural modifications and retain the maximum number of original scooter components to reduce conversion cost.

9. To evaluate the performance of the retrofitted scooter in terms of speed, range, power consumption, and overall efficiency.

10. To develop a cost-effective and environmentally friendly electric scooter that promotes sustainable transportation.

III. METHODOLOGY

The methodology adopted for the retrofitting of a conventional SI scooter into an electric drive system consists of the following stages:

1. Vehicle Selection

A conventional SI scooter in good structural condition is selected for retrofitting. The chassis, suspension, brakes, and frame are inspected to ensure suitability for conversion.

2. Removal of IC Engine Components

The internal combustion engine and associated components, including the fuel tank, exhaust system, carburetor, air filter, fuel lines, and engine wiring, are removed while retaining the original chassis and mechanical structure.

3. Selection of Electric Drive Components

The major electric drive components are selected based on the vehicle's performance requirements. These include:

- Hub motor
- Lithium-ion battery pack
- Motor controller
- Battery Management System (BMS)
- Battery charger
- Throttle and electrical wiring

4. CAD Design and Structural Modification

Computer-Aided Design (CAD) software is used to model the modified scooter. The battery mounting bracket, swing arm (if required), and supporting structures are designed to ensure proper fitment, strength, and weight distribution.

5. Fabrication and Assembly

The designed brackets and supporting components are fabricated using suitable materials. The hub motor, battery pack, controller, BMS, and other electrical components are

assembled and securely mounted on the scooter.

6. Electrical Integration

The electrical system is connected according to the circuit design. Proper wiring, insulation, fuse protection, and safety measures are implemented to ensure reliable operation.

7. Testing and Performance Evaluation

The retrofitted scooter is tested under different operating conditions. Key performance parameters such as maximum speed, driving range, battery performance, power consumption, braking, and vehicle stability are evaluated.

8. Cost and Performance Analysis

The retrofit system is analyzed in terms of conversion cost, operating cost, energy efficiency, maintenance requirements, and environmental benefits. The results are compared with those of the original SI scooter to determine the feasibility and effectiveness of the retrofit.



Figure 1 AFTER RETROFITTING ELECTRIC SCOOTER

IV. LITERATURE REVIEW

The increasing demand for sustainable transportation has led researchers to investigate the conversion of conventional internal combustion engine (ICE) vehicles into electric vehicles (EVs). Retrofitting has gained attention as a cost-effective solution that extends the service life of existing vehicles while reducing emissions and dependence on fossil fuels.

Several studies have reported that electric vehicle retrofitting is technically feasible when appropriate electric drive components, such as hub motors, lithium-ion battery packs, motor controllers, and Battery Management Systems (BMS), are properly selected and integrated. Researchers have shown that hub motors simplify the drivetrain by eliminating the need for complex transmission systems, resulting in reduced maintenance and improved overall efficiency.

The selection of the battery pack plays a significant role in determining the vehicle's range, performance, and reliability. Recent studies indicate that lithium-ion batteries are the preferred choice because of their high energy density, low weight, long cycle life, and fast charging capability. The inclusion of a Battery Management System (BMS) further enhances battery safety and operational efficiency by monitoring voltage, current, and temperature.

Researchers have also emphasized the importance of structural modifications during retrofitting. The design of battery mounting brackets, swing-arm modifications, and proper weight distribution are essential for maintaining vehicle stability and rider safety. Computer-Aided Design (CAD) and Finite Element Analysis (FEA) are widely used to validate these modifications before fabrication.

Performance evaluations conducted in previous studies have demonstrated that retrofitted electric scooters can achieve satisfactory speed, acceleration, and driving range while significantly reducing operating costs and maintenance requirements. Economic analyses have shown that retrofitting is often more affordable than purchasing a new electric scooter, making it a practical option for users in developing countries.

Although considerable research has been conducted on electric vehicle conversion, limited studies focus specifically on the complete retrofitting of conventional SI scooters using hub motors along with detailed CAD-based structural modifications and performance analysis. Therefore, the present study aims to bridge this gap by developing, fabricating, and evaluating a reliable and cost-effective electric scooter retrofit system.

1. Sharma and Gupta (2021)

Sharma and Gupta investigated the conversion of a petrol-powered scooter into an electric scooter using a BLDC hub motor and lithium-ion battery pack. Their study demonstrated that retrofitted electric scooters achieved satisfactory performance for urban transportation with reduced operating costs and zero tailpipe emissions.

Findings:

- Reduced running cost by approximately 70%.
- Elimination of fuel consumption.
- Improved energy efficiency.

2. Patel et al. (2020)

Patel and co-researchers developed a retrofitted electric two-wheeler using a 1.5 kW BLDC motor and 48 V battery system. The study evaluated speed, acceleration, and battery discharge characteristics.

Findings:

- Maximum speed achieved: 50 km/h.
- Vehicle range: 60 km per charge.
- Reduced maintenance compared to conventional scooters.

3. Singh and Verma (2019)

The researchers analyzed the economic feasibility of converting existing scooters into electric scooters. The study compared the lifecycle costs of conventional and retrofitted vehicles.

Findings:

- Payback period of approximately 2–3 years.
- Significant reduction in operating expenses.
- Conversion cost lower than purchasing a new EV.

Study on Battery Technologies for Electric Scooters

Researchers compared various battery technologies:

Battery Type	Energy Density	Life Cycle	Cost
Lead Acid	Low	Low	Low
Nickel Metal Hydride	Medium	Medium	Medium
Lithium-Ion	High	High	High
Lithium Ferro Phosphate (LFP)	Very High	Very High	Medium

Findings Lithium-Ion batteries were found to be most suitable because:

- Lightweight
- High energy density
- Fast charging capability
- Long service life

For scooter retrofitting, battery capacities between 48V–72V and 20Ah–40Ah were commonly recommended. Proper design and CAD modification ensure vehicle stability, safety, and durability.

1 Need for Swing Arm Modification

The original swing arm of a conventional scooter is designed for:

- IC engine power transmission
- Rear wheel support
- Existing vehicle weight distribution After

retrofitting:

- Hub motor increases unsprung mass.
- Battery pack changes vehicle center of gravity.
- Additional brackets may be required.
- Suspension mounting points may need adjustment.

- Structural strength must be verified.

Therefore, modification of the swing arm becomes necessary.

2 Design Considerations

The following factors were considered during swing arm redesign:

2.1 Strength

The swing arm should withstand:

- Vehicle weight
- Rider weight
- Battery weight
- Motor torque
- Road impact loads

2.2 Rigidity

Excessive deformation may cause:

- Wheel misalignment
- Poor handling
- Reduced stability

PROPOSED DESIGN

The swing arm is one of the most important structural components in a scooter. In the project "Retrofitting of Conventional SI Scooter into an Electric Drive System", the original swing arm may require modification to accommodate the hub motor, battery weight distribution, and altered load.

2.3 Weight Reduction

The modified swing arm should:

- Minimize additional weight
- Maintain structural integrity

2.4 Ease of Fabrication The design should:

- Use locally available materials
- Require minimum machining
- Be suitable for welding operations

Selection

Property	Value
Material	Mild Steel (IS 2062)
Yield Strength	250 MPa
Ultimate Strength	410 MPa
Density	7850 kg/m ³
Young's Modulus	200 GPa

Reason for Selection:

- Easy availability
- Good weldability
- Low cost
- Adequate strength

4. Load Calculations Vehicle Parameters

Parameter	Value
Vehicle Weight	95 kg
Rider Weight	75 kg
Battery Weight	25 kg
Hub Motor Weight	12 kg
Total Weight	207 kg

Total Load:

$$W=207 \times 9.81 \quad W=2030.67N$$

$$\text{Rear wheel load (60\%): } W_r=0.6 \times 2030.67 \quad W_r=1218.4N$$

$$\text{Considering dynamic factor} = 2 \quad W_d=2 \times 1218.4$$

$$W_d=2436.8N$$

The swing arm is designed for approximately 2.5 kN load.

5. CAD Modeling Procedure

The swing arm model was developed using CAD software such as: SolidWorks

Step 1

Take a measurements for Swing Arm Step 2

Create 2D sketch.



Fig.no 7.6 Create 2D sketch.

Step 3

Generate 3D model.

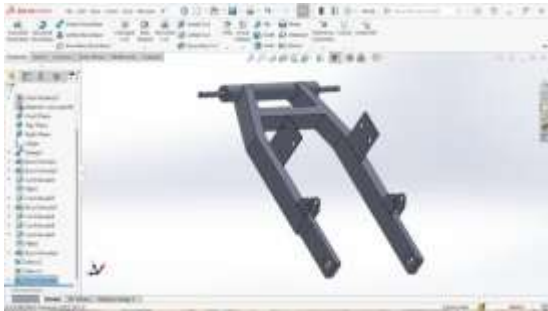
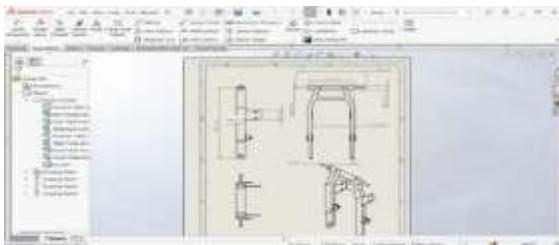


Fig.no 7.6 Generate 3D model.



Step 4 Add:

- Hub motor mounting holes
- Reinforcement plates
- Gussets
- Suspension brackets Step 5

Perform interference check. Step 6

Finalize assembly.

V.CONCLUSION

The project “Retrofitting of Conventional SI Scooter into an Electric Drive System” successfully demonstrates the feasibility of converting a conventional petrol scooter into an electric vehicle using a hub motor, battery pack, motor controller, throttle system, and associated electrical components. The conversion eliminates the need for fossil fuels, significantly reduces exhaust emissions, and lowers operating and maintenance costs.

The retrofitted electric scooter provides smooth operation, quiet performance, and satisfactory speed for urban transportation requirements. The use of a hub motor simplifies the drivetrain mechanism by eliminating complex transmission components, thereby increasing reliability and reducing maintenance requirements.

This project highlights an effective solution for utilizing existing vehicle structures while supporting environmental sustainability and energy conservation. Retrofitting offers a cost-effective alternative to purchasing new electric vehicles

and contributes to reducing air pollution and dependence on conventional fuels.

Overall, the project proves that retrofitting conventional SI scooters into electric scooters is a technically viable, economically beneficial, and environmentally friendly approach that can play a significant role in the future growth of electric mobility and sustainable transportation systems.

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