IMPLEMENTATION OF ECO-FRIENDLY RETROFIT ELECTRIC TVS XL MOPED

PROJECT PHASE II REPORT

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BONAFIDE CERTIFICATE

Certified that his project report **"IMPLEMENTATION OF ECO-FRIENDLY RETROFIT ELECTRIC TVS XL MOPED"** is the bonafide work of "**R.DILIP(20105102), D.HARIHARAN(201051038), M.KAMALESH(201051043), E.BALAMURUGAN(201053810)** who carried out the Project Work (Phase- II)/Project Work under my/our supervision.

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

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MAHENDRA ENGINEERING COLLEGE

(Autonomous)

Department Of Electrical And Electronics Engineering

VISION

- To produce globally competent Electrical and Electronics Engineers, entrepreneurs with cutting-edge technologies

MISSION

- To impart technical education through effective teaching-learning process
- To enhance students employability through mentoring various skill based activities
- To promote research activities with a focus on excellence and innovation to meet the global challenges
- To imbibe ethical and enterprising characters to become socially responsible citizens

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

The graduates of Electrical and Electronics Engineering will be able to,

PEO1: Excel in professional career by applying the knowledge to meet the real time challenges.

PEO2: Apply Electrical and Electronics expertise and research to solve interdisciplinary issues.

PEO3: Exhibit soft skills, professional ethics and an ability for life-long learning to resolve societal causes.

PROGRAM OUTCOMES (POs)
Engineering Graduates will be able to:

1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. Problem analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

6. The Engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

The students will demonstrate the abilities

PSO1: Understand and apply core domain knowledge of electrical engineering to analyse and solve complex engineering problems of machines, control systems, electronics and power systems.

PSO2: Apply proficient innovative solutions in renewable energy for specific requirements.

PSO3: Create conducive environment to develop professionalism, entrepreneurial skills and leadership qualities with ethics.

COURSE OUTCOMES (COs)

The students will be able to,

- Identify the real-time / problems in area of interest.
- Review literature for the project work.
- Analyze the results to draw valid conclusions.
- Develop prototypes/models, experimental set-up and prepare a report.
- Explore the possibility of publishing papers in peer reviewed journals/conference proceedings.

ABSTRACT

The growing demand for sustainable and eco-friendly transportation solutions has prompted the exploration of Electric Vehicle (EV) conversions as a viable option for enhancing the environmental performance of existing Internal Combustion Engine (ICE) vehicles. This project on the development of a retrofit electric conversion kit tailored for the TVS XL moped a popular and widely used two-wheeler in many regions. The retrofit kit aims to seamlessly integrate an electric powertrain into the existing TVS XL framework, ensuring minimal modifications to the original design while maximizing the benefits of electrification. The conversion process involves the integration of a high-performance electric motor, a compact and efficient battery pack, and an intelligent control system. The project is designed for user-friendly, allowing moped owners to upgrade their vehicles with minimal technical expertise. The Key objectives of the research include optimizing the electric powertrain for the TVS XL moped to maintain orimprove its overall performance metrics, including speed, range, and load capacity. Additionally, considerations are made for the development of a regenerative braking system to enhance energy efficiency and extend the overall range of the converted moped. This project combines the theoretical analysis, computer simulations, and practical experiments to validate the performance andreliability of the retrofit kit. The outcomes of this project aim to contribute valuable insights into the development of retrofit electric conversion kits for conventional mopeds, particularly the TVS XL. The successful implementation of the project play a significant role in reducing the carbon footprint of existing fleets and promoting the widespread adoption of electric mobility in the two- wheeler segment.

TABLE OF CONTENTS

LIST OF FIGURE

LIST OF TABLE

LIST OF ABBREVIATION

1	AC	-	Alternating Current
2	BLDC	-	Brushless Dc Motor
3	CO_2	-	Carbon Dioxide
4	DC	-	Direct Current
5	EV	-	Electric Vehicle
6	EPK	-	Electric Propulsion Kit
7	EOL	-	End Of Line
8	EM	-	Electric Motorbike
9	FTV	-	Fleet Test Vehicle
10	GHG	-	Greenhouse Gas
11	HEV	-	Hybrid Electric Vehicles
12	LED	-	Light Emitting Diode
13	LCA	-	Life Cycle Assessment
14	g	-	Acceleration Due to Gravity
15	PHEV	-	Plug-In Hybrid Electric Vehicles
16	PM	-	Particulate Matter
17	C_{rr}	-	Coefficient of Rolling Resistance
18	A(F)	-	Frontal Area
19	ρ	-	Air Density
20	v	-	Velocity
21	C_d	-	Drag Coefficient

CHAPTER 1

INTRODUCTION

The escalating concerns surrounding environmental sustainability and the imperative shift towards cleaner transportation have intensified the exploration of innovative solutions within the automotive industry. Among these solutions, the retrofitting of Internal Combustion Engine (ICE) vehicles with electric powertrains emerges as a promising avenue for achieving a rapid transition to eco-friendly mobility. This research focuses on the Development of a Retrofit Electric Conversion Kit for the TVS XL Moped a ubiquitous and widely utilized two-wheeler renowned for its reliability and fuel efficiency. As the global transportation sector grapples with the challenges of carbon emissions, air pollution, and finite fossil fuel resources, the imperative to electrify existing vehicle fleets becomes increasingly evident. The TVS XL Moped, a staple in many urban and rural settings, represents a considerable portion of the two-wheeler market. Transforming this iconic and widely adopted moped into an electric vehicle through retrofitting presents an exciting opportunity to significantly contribute to the paradigm shift toward sustainable transportation. The motivation behind this research stems from the recognition that retrofitting offers a pragmatic and cost-effective approach to integrating electric mobility into existing transportation infrastructure. Unlike introducing entirely new electric vehicles, retrofitting leverages the familiarity and longevity of well-established models, reducing the need for extensive infrastructure changes and promoting the widespread adoption of electric technology. This study seeks to address the multifaceted challenges associated with developing a retrofit electric conversion kit specifically tailored for the TVS XL Moped. These challenges include the seamless integration of an electric powertrain into the moped's architecture, ensuring optimal performance metrics, maintaining user-friendly installation processes, and evaluating the economic feasibility of the conversion.

Furthermore, considerations for environmental sustainability and life cycle emissions are integral aspects of this research, reinforcing the commitment to a holistic and responsible approach to electric vehicle development. By delving into the Development of a Retrofit Electric Conversion Kit for the TVS XL Moped, this research endeavours to contribute not only to the niche of two-wheeler electrification but also to the broader discourse on sustainable mobility. The outcomes of this endeavour are anticipated to offer valuable insights, guidelines, and a tangible solution that can be replicated across various conventional two-wheelers, fostering a tangible and impactful transition towards a cleaner and more sustainable future for urban and rural transportation alike.

CHAPTER 2

LITERATURE REVIEW

1. Mahesh, L., Anand, S., Nagishetty Chandrakanth, H., Reddy, H., & Karthik, M,2023

The escalating concerns over the environmental impact of fossil fuel emissions have driven a significant paradigm shift within the automotive sector, with a growing emphasis on alternative energy sources. This literature review explores the contemporary landscape of research and development pertaining to the transition from traditional gasoline vehicles to electric alternatives, focusing on the specific case of retrofitting the TVS XL Moped. The global push towards reducing dependency on fossilfuels has prompted a surge in research and development within theautomobile sector, with a primary focus on Electric Vehicles (EVs). Researchers and developers are actively engaged in designing new electric bikes, reflecting the industry's inclination towards creating a sustainable and eco-friendly mode of transportation.

In the context of India, the increasing cost of petrol poses a significant economic challenge, particularly for segments of the population, such as farmers. The financialstrain of purchasing new electric bikes remains a hurdle, leading to a search for innovative solutions that alleviate the economic burden on consumers, while also promoting sustainable mobility. The majority of Indian farmers, who rely extensively on two-wheelers for their day-to-dayactivities, often opt for the TVS XL Moped. In response to the economic constraints faced by farmers and the environmental implications of fossilfuel use, this paper introduces a novel approach. The modification of the TVS XL Moped involves replacing the internal combustion engine with an electric motor. A key technical aspect addressed in this paper is the choice of power transmission mechanism.

The design for a chain drive to transfer power from the electric motor to the drive shaft. Comparative analysis suggests that this approach when juxtaposed with ahub-mounted electric motor, proves to be more economical. This decision is pivotal, not only in terms of cost-effectiveness but also in ensuring the feasibility and practicality of the retrofitting process.

The primary motivation behind converting the gasoline engine into an electric drive ismultifold. Firstly, it aims to alleviate the financial burden on farmers by offering a more economical solution. Secondly, this transition addresses environmental concerns by reducing pollution and saving material wastage, aligning with sustainable practices and contributing to the circular economy. In summary, the literature review highlights the globalmovement towards electric vehicles, the challenges faced in the Indian context, and the innovative retrofitting approach applied to the TVS XL Moped. This Project not only demonstrates the technical aspects of theretrofit but also underscores the economic and environmental motivations for transitioning from traditional gasoline vehicles to electric alternatives.

2. Nandedkar, M. Wagh, N. and Rege, S., 2017

The advent of Electric Vehicles (EVs) marks a transformative era in the automotive industry, driven by a global push towards sustainable and eco-friendly transportation solutions. This literature review explores the challenges associated with current EV battery technology. The key component in an EV, therechargeable battery, plays a crucial role in the system's overall performance, including the operation of the electric motor and auxiliary components. However, the current state of EV technology presents challenges such as heavyweight, poor durability, and high total cost due to the large number of batteries needed to support an EV's operation Recognizing the limitations of existing EV batteries, the paper emphasizes the importance of enhancing battery energy capacity for achieving extended range operations. The need to tackle issues of heavyweight, poor durability, and high total cost becomes imperative for the widespread adoption and success of EV technology. The paper employs simulation techniques to analyze the performance of an Electric Motorbike (EM) in terms of power requirements for maneuvering a specific range. According to the simulation results, the EM requires an average power of 2069 Watts to cover a distance of 65.3 km.

The simulation serves as a valuable tool for understanding the power dynamics and requirements of the EV in real-world scenarios. A noteworthy aspect of the paper is the comparison between field test data and simulation results, revealing a discrepancy of 7%. This variance indicates the complexities involved in translating simulation findings into practical, on-road performance. This raises questions about the accuracy and reliability of simulation models in predicting real-world EV behavior. The study identifies the target audience for EVs as individuals living in urban areas. Urban dwellers, facing issues of traffic congestion and parking shortages, are considered the primary beneficiaries of EV technology. This aligns with global trendswhere countries are increasingly focusing on urban-centric EV policies and infrastructure development. The literature notes the proactive stance of governments worldwide, including Malaysia, towards promoting EVs.

The Fleet Test Vehicle (FTV) Programme in Malaysia, initiated by the Ministry of Energy, Green Technology, and Water, exemplifies efforts to achieve a 15% EV usage target by 2020. This aligns with global initiatives, reinforcing the growing momentum towards a sustainable and green transportation landscape . Highlighting the popularity of motorcycles in Asian countries for urban commuting, the paper underscores the preference for two-wheelers due to their smaller size, convenience for short-distance travel, and agility in navigating traffic congestion. The study points out that motorcycles, especially electric ones, could significantly contribute to reducing the transportation burden in urban areas.

The literature review concludes by emphasizing the urgency to address challenges in current EV battery technology. As countries globally strive towards Sustainable Development Goals and thephasing out of traditional fuel-based vehicles, the evolution of EVs, coupled with technological advancements, emerges as a crucial driver forachieving a sustainable future.In summary, the literature review highlights the importance of enhancing EV battery capacity, using simulation-based analysis, understanding discrepancies between simulation and real-world performance, targeting urban populations, and recognizing the role of motorcycles in shaping sustainable urban mobility. The paper contributes valuable insights into the challenges and opportunities in the ongoing evolution of electric vehicles.

3. Devendra Vashist,et.al,2019

In the context of India, where two-wheelers dominate urban transportation, constituting approximately 70% of the auto market, the need for sustainable and environmentally friendly alternatives is paramount. This literature survey explores the current landscape of research focusing on the replacement of conventional Internal Combustion (IC) Engines with electric DC motors in two-wheelers, with a particular emphasis on design considerations, torque requirements, and the potential for retrofitting existing bikes. Two-wheelers stand as the primary mode of single-person transport in Indian metros, playing a pivotal role in addressing the last-mile connectivity needs of urban dwellers.The significant market share underscores the urgency to explore sustainable alternatives, given their substantial contribution to environmental emissions. Extensive research indicates that, per unit energy consumption, conventional engine-based two-wheelers contribute disproportionately to environmental emissions.This understanding forms the basis for transitioning to electric propulsion systems as a means to mitigate environmental impact and promote sustainable mobility. The proposed solution involves replacing the traditional IC engine with an electric DC motor powered by chargeable batteries. This transformative approach aims to reduce emissions, improve energy efficiency, and alignwith the global shift towards electric mobility.

The research involves the integration of an electric DC motor, batteries, and a controller, replacing the conventional IC engine. This not only necessitates a technological shift but also requires a redesign of the vehicle structure to accommodatethe new components, ensuring seamless integration and optimal performance. The study evaluates the torque requirements of the electric motor on different gradients to identify the minimum and maximum resistances encountered on the road. Understanding these torque requirements is crucial for optimizing motor performance and ensuring efficient operation across diverse terrains. An important aspect of the research is the consideration of the proposed system as a retrofit solutionfor existing IC engine bikes. This approach acknowledges the existing fleet of vehicles on the road and seeks to provide a feasible and sustainable path for their transformation into electric bikes.

The research contributes valuable insights into the design calculations necessary for the development of electric two-wheelers. It emphasizes the selection of an appropriate motor, taking into account torque requirements and variable resistances encountered during real-world usage. These insights serve as a foundational guide for future designs in the evolving landscape of electric mobility. In conclusion, the literature survey underscores the critical role of electrification in mitigating the environmental impact of two-wheelers in Indian metros. The proposed system, involving the replacement of IC engines with electric DC motors, not only addresses the environmental concerns but also provides practical insights into torque requirements, retrofitting strategies, and design considerations. This research lays the groundwork for future advancements in the design and implementation of electric two-wheelers, contributing to the broadernarrative of sustainable urban mobility.

4. **Muhammad Idris, Raldi Hendro Koestoer, et al, 2023**

The paper authored by Muhammad Idris, Raldi Hendro Koestoer, et al., titled "Environmental Assessment of Conventional IC Engine Two-Wheelers in Urban Settings," published in Environmental Science and Technology, provides a comprehensive examination of the environmental impact associated with traditional Internal Combustion (IC) Engine-based two-wheelers within urban contexts. The study commences by acknowledging the pivotal role of two-wheelers in urban transportation, emphasizing their dominance in the vehicle market. With two-wheelers comprising a substantial portion of urban fleets, the research underscores the necessity for a thorough investigation into their environmental consequences. Muhammad Idris, Raldi Hendro Koestoer, et al., define the scope of the environmental assessment, elucidating the pollutants and factors considered in evaluating the ecological footprint of conventional IC engine two-wheelers.

The analysis likely includes criteria pollutants such as Nitrogen Oxide (NOx), Particulate Matter (PM), and Carbon Dioxide (Co_2), among others. The authors likely conduct a comparativeanalysis among various types and models of IC engine two-wheelers, examining factors like emission rates, fuel efficiency, and overall environmental impact. This comparative approach offers insights into variations among different models, highlighting potential areas for improvement. Recognizing the unique challenges posed by urban settings, the paper likely explores how the environmental impact of IC engine two-wheelers is exacerbated in densely populated areas. Factors such as traffic congestion, stop-and-go traffic patterns, and limited greenspaces are likely discussed concerning heightened emissions and air quality degradation. The literature review delves into existing and proposed emission control strategies for IC engine two-wheelers in urban environments. Technological advancements, regulatory measures, and alternative fuels are likely discussed as potential avenues to mitigate the environmental impact of these vehicles. The paper likely discusses the policy implications derived from the environmental assessment. Insights into the effectiveness of existing environmental policies, as well as recommendations for future regulatory frameworks, contribute to the broader discourse on sustainable urban mobility. Details on the methodology employed for the environmental assessment are likely included.

This may encompass measurement techniques, data collection processes, and modeling approaches used to quantify emissions andassess the overall environmental performance of IC engine two-wheelers.The literature review likely acknowledges the limitations and challenges encountered during the environmental assessment. These could include constraints in data availability, uncertainties in model predictions, or difficulties in obtaining accurate real-world emission data. As with many environmental assessments, the paper likely suggests future research directions. This could involve areas such as emerging technologies, alternative propulsion systems, and comprehensive life cycle analyses aimed at further improving the sustainability of two-wheelers.

5. **Małgorzata Mrozik and Agnieszka Merkisz-Guranowska,2021**

The significance of environmental safety in the automotive industry has grown exponentially, reflecting consumer demands and global environmental concerns. In this context, the article by Małgorzata Mrozik and Agnieszka Merkisz-Guranowska delves into the environmental assessment of combustion-powered cars during their operation. The authors argue that evaluating ecological properties, especially pollutant emissions and operational fuel consumption, is pivotal in determining the overall competitiveness and quality of a vehicle in the consumer market. A core theme in the article is the exploration of the Life Cycle Assessment (LCA) method for analysing the ecological properties of passenger cars during their operation. The LCA method, a widely accepted approach for evaluating the environmental impact of products, is adapted for vehicles.

The authors present a simplified LCA method tailored to the analysis of environmental impact and energy assessment during a car's operation. The authors develop a vehicle life cycle model, specifically designed to account for environmental loads related to fuel consumption, pollutant emissions from internal combustion engines, and maintenance processes. This model becomes the basis for analyzing data from 33 passenger cars with similar operational characteristics from different manufacturers andproduction periods. The central findings of the study highlight the paramount role of the operational phase in a car's life cycle concerning its impact on the environment. Through a comprehensive analysis of 33 vehicles, the study emphasizes the significance of mileage, determined byperiodic replacement of elements and materials prone to wear, and the length of the operational period.

The study concludes that, for the annualoperation period, energy inputs and related emissions, primarily resultingfrom fuel consumption, play a crucial role in a car's environmental impact. Approximately 94% to

96% of the total input during of the vehicle is attributed to energy input, CO_2 emissions, and SO_2 emissions. In conclusion, the literature review of Małgorzata Mrozik and Agnieszka Merkisz-Guranowska's article underscores the importance of the LCA method in assessing the environmental impact of combustion- powered vehicles during their operational phase. The findings emphasize the need for a holistic perspective, taking into account fuel consumption, pollutant emissions, and maintenance processes to comprehensively evaluate a car's ecological footprint throughout its life cycle.

6. **Shafayat Rashid ,Emanuele Pagone,2023**

The escalating demand for sustainable transportation, coupled with a reduction in environmental impact, has steered the automotive industry towards the widespread adoption of electrified powertrains. Hybrid Electric Vehicles (HEVs) and Plug-In Hybrid Electric Vehicles (PHEVs) have emerged as promising solutions, demonstrating lower Greenhouse Gas (GHG) emissions during the use phase of their lifecycle compared to conventional Internal Combustion Engine Vehicles (ICEVs). However, a comprehensive understanding of their total environmental impact, spanning from resource extraction to End-Of-Life (EOL), remains a gap in the scientific literature. In this groundbreaking work, a systematic cradle-to-grave Life Cycle Analysis (LCA) was conducted for a real-world ToyotaPrius XW50, serving as both a HEV and PHEV.

The study aimed to comprehensively assess the vehicle's environmental impact throughout its entire lifecycle, utilizing established lifecycle inventory databases. The LCA findings unveiled a notable environmental impact "hotspot" within the gasoline fuel cycle, encompassing extraction, refinement, andtransportation. This discovery underscores the need for a holistic assessment that considers the entire lifecycle, not just the use phase, to address the true environmental impact of vehicles. Contrary to the prevailing assumption that PHEVs invariably exhibit a higher environmental impact due to larger traction batteries, the study presenteda nuanced perspective. The more electrified PHEV model was found to consume 3.2% more energy and emit 5.6% more greenhouse gas emissions withinthe vehicle's lifecycle, primarily attributed to the manufacturing and recycling processes of larger batteries. When accounting for the fuel cycle, a crucial aspect often overlooked in traditional assessments, the PHEV model demonstrated a 29.6% reduction in overall cradle-to-gravelife energy consumption and a 17.5% reduction in GHG emissions compared to the less-electrified HEV.

This indicates that the higher-electrified PHEV, despite its larger battery impact, exhibits a lower environmental impact than the HEV throughout the entire lifecycle. Thepresented cradle-to-grave LCA study serves as a pioneering benchmark for future research. It emphasizes the importance of considering the entire lifecycle and fuel cycle in assessing environmental impacts. This methodology can be instrumental in comparing various HEVs, PHEVs, or different powertrains for similarly sized passenger vehicles, providing valuable insights for sustainable mobility.

CHAPTER 3

EXISTING SYSTEM

3.1 BLOCK DIAGRAM OF EXISTING SYSTEM

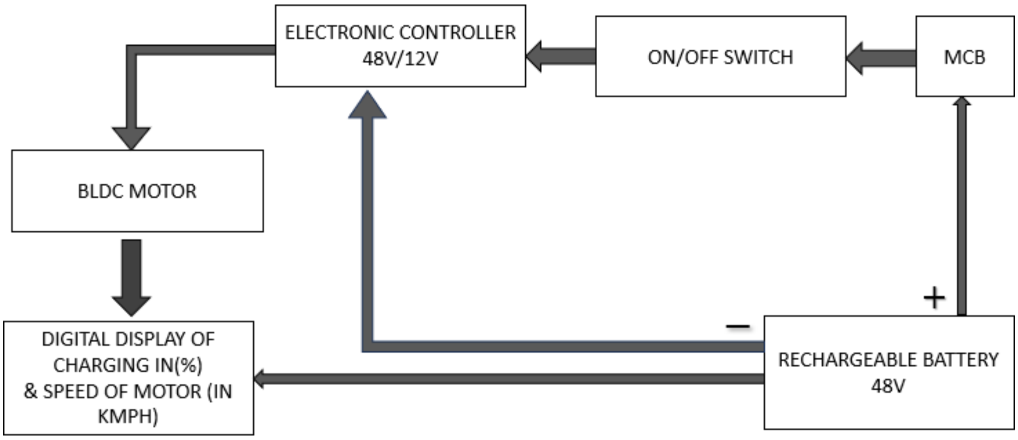

Fig. 3.1 Block diagram of Existing System

3.2 EXPLANATION OF EXISTING SYSTEM

The existing system for the development of retrofit electric TVS XL mopeds involves a transformative process where traditional TVS XL mopeds, originally powered by Internal Combustion Engines, are converted into electric vehicles. The driving force behind this retrofitting initiative is rooted in the desire to make electric mobility more financially accessible and environmentally sustainable. The primary consideration in opting for retrofitting is the economic aspect. Purchasing new electric bikes is often cost-prohibitive for many, particularly farmers.

Retrofitting existing mopeds presents a more budget-friendly option, enabling a wider demographic to embrace electric mobility. From an environmental perspective, the retrofitting project is geared towards reducing the ecological footprint associated with conventional gasoline-poweredmopeds. The shift to electric power aligns with broader global efforts to minimize pollution and promote sustainable transportation solutions, contributing to a cleaner and greener environment. Extending the product life cycle of TVS XL mopeds is another key aspect of the retrofitting initiative. Rather than discarding old gasoline-powered vehicles, the retrofitting process breathes new life into these mopeds, fostering both sustainability and economic efficiency for the company and the country.

The project also addresses concernsrelated to fuel dependency. With the constant rise in oil prices and the eventualdepletion of oil resources, there is a pressing need for alternative energy sourcesin the automobile sector. Electric vehicles, including retrofitted mopeds, provide a practical solution by harnessing electric power from the grid, solar panels, andother non-conventional sources. Advancements in electric motor technology, particularly lithium-ion batteries and Brushless DC motors, play a crucial role in the retrofitting process.

These technological developments contribute to the design and implementation of efficient electric bikes. The support from the Indian government in developing infrastructure for electric vehicles further enhances the feasibility of the retrofitting project. Moreover, the retrofitting initiative aims to overcome limitations associated with commercially availableelectric bikes, such as extended charging times, limited travel distance, lower speed, and high initial investment.

By retrofitting existing mopeds, the project endeavors to make electric mobility more practical and appealing, addressingthese concerns and making it a viable option for a broader audience. In essence,the development of retrofit electric TVS XL mopeds is a comprehensiveapproach that tackles economic, environmental, and accessibility challenges linked to traditional internal combustion engine vehicles. This initiative reflectsa broader global trend toward embracing sustainable and electric transportationsolutions.

3.3 PROBLEM STATEMENT

The retrofitting of traditional TVS XL mopeds into electric vehicles faces several intricate challenges that demand meticulous attention and strategic solutions to ensure successful implementation. The primary obstacle lies in the substantial upfront cost associated with converting conventional TVS XL mopeds into electric vehicles. This financial barrier poses a significant challenge, particularly for individuals and farmers with limited economic resources, hindering the widespread adoption of electric retrofitting. A considerable lack of awareness about the advantages and feasibility of retrofitting exists among potential users. Bridging this awareness gap is crucial to facilitate the acceptance and adoption of electric retrofitting among the target demographic.

Integrating modern electric vehicle technology, including lithium-ion batteries and Brushless DC motors, into the existing framework of TVS XL mopeds demands intricate engineering. Overcoming technical challenges and ensuring seamless integration are pivotal for the success of the retrofitting initiative. The absence of a well-established charging infrastructure for retrofitted electric mopeds poses a significant impediment. Developing an efficient network of charging stations is imperative to address the practicality concerns associated with electric vehicle usage. Concerns related to the travel range on a single charge and the overall efficiency of batteries need focused attention. Overcoming these challenges is essential to enhance the practicality and appeal of retrofitted electric TVS XL mopeds.

Performing a comprehensivelife cycle analysis to verify the actual reduction in environmental footprint compared to traditional vehicles adds a layer of complexity. Ensuring the genuine sustainability benefits of retrofitting is critical for the credibility of theinitiative. Existing regulatory frameworks and policies may not be conducive tothe development of retrofit electric TVS XL mopeds. The lack of supportive policies and incentives could impede the wider adoption of this environmentally friendly solution. Building trust among potential users regarding the performance, reliability, and safety of retrofitted electric mopeds is a significantchallenge. Overcoming skepticism and shaping positive consumer perceptions are crucial for market acceptance. Establishing a robust and consistent supply chain for electric vehicle components, especially batteries and motors, presentslogistical challenges. Ensuring a stable supply is fundamental for the scalabilityand sustainability of the retrofitting initiative.

Assessing and guaranteeing the long-term economic viability, including ownership costs, is a critical concern. Demonstrating that the overall cost of ownership is competitive with traditionalmopeds is essential for encouraging broader market acceptance. Addressing these intricate challenges requires a holistic and interdisciplinary approach, involving technological innovation, policy advocacy, and community engagement. Successful resolution of these issues will be instrumental in establishing retrofit electric TVS XL mopeds as a feasible, sustainable, and widely accepted mobility solution.

CHAPTER 4

PROPOSED SYSTEM

4.1 BLOCK DIAGRAM OF PROPOSED SYSTEM

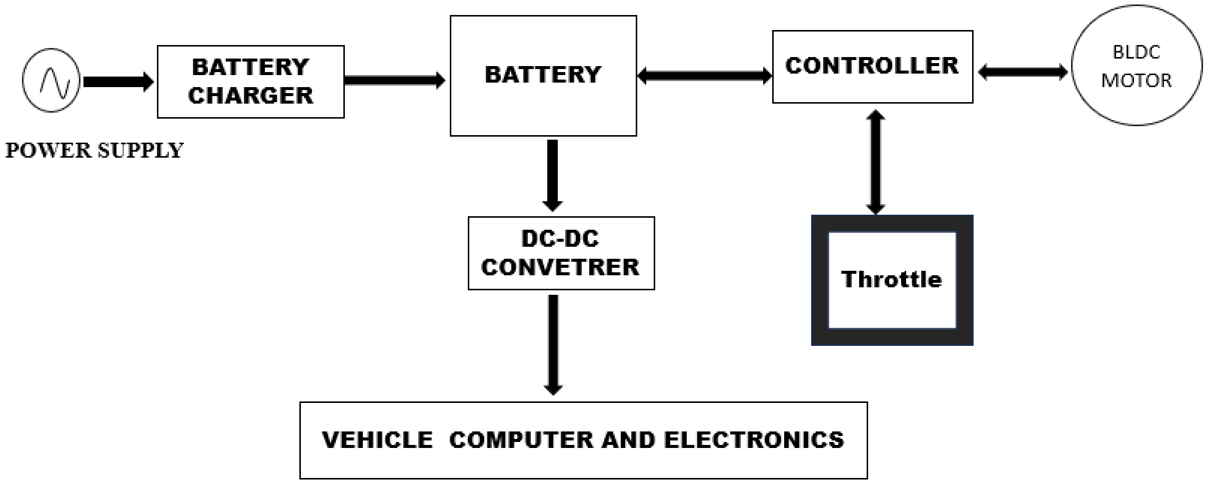

Fig. 4.1 Block diagram of Proposed System

4.2 DESCRIPTION OF PROPOSED SYSTEM

The proposed system for the development of retrofit electric TVS XL mopeds aims to address the identified challenges and objectives comprehensively. The key aspects of the proposed system include technological innovation, design efficiency, economic viability, and environmental sustainability. The conversionprocess involves a meticulous transformation of the Internal Combustion Engine (ICE) TVS XL moped into an electric-powered vehicle. This conversion includes the removal of the IC engine and its replacement with an electric motor.

The process ensures the preservation of the vehicle's original design and structure tomaintain its aesthetic and functional integrity. The proposed system maximizesthe use of all available vehicle spares to minimize waste and promote efficient resource utilization. Components such as the chassis, suspension, and braking systems are retained, optimizing the conversion process without

Compromising safety or performance. Desired design upgrades are incorporated without altering the fundamental structure of the moped. The retrofitting process includes the integration of advanced electric vehicle components, such as lithium-ion batteries and efficient Brushless DC motors, to enhance overall performance while adhering to the original design aesthetics. Efforts are directed towards reducing the charging time of the electric vehicle batteries, enhancing efficiency, and minimizing the overall cost of the charging process.

This involves the integration of fast-charging technologies and exploring cost- effective battery solutions, ensuring a practical and economical electric retrofitting solution. The proposed system includes a comprehensive analysis of the dynamic performance of the retrofitted electric TVS XL moped. This involves testing the vehicle under various conditions, including different gradients and load capacities. Performance metrics such as acceleration, braking, and overall handling are meticulously evaluated to ensure optimal functionality.The core objective of the proposed system is to contribute to a green and pollution-free environment. By converting IC vehicles into electric-powered ones, the system aligns with global efforts to reduce carbon emissions and air pollution. The use of electric vehicles promotes sustainable and eco-friendly transportation.

To address the charging infrastructure deficiency, the proposed system includes initiatives to develop a network of charging stations. Strategic placement of these stations in urban and rural areas facilitates convenient and widespread use of retrofitted electric mopeds. Community engagement programs are integrated into the proposed system to raise awareness about the benefits of electric retrofitting. Workshops, educational campaigns, and outreach activities aim to inform potential users about the advantages, dispelling misconceptions and fostering acceptance. The proposed system includes advocacy efforts to influence regulatory frameworks and policies to be more conducive to electric vehicle retrofitting. Collaborations with government bodies and policy-makers aim to establish supportive environments and incentivize the adoption of retrofitted electric vehicles. Economic viability is ensured through a meticulous assessment of the long-term cost-effectiveness of a retrofitted electric TVS XL moped.

This includes considerations of maintenance costs, operational expenses, and potential economic incentives for users, demonstrating the financial feasibility of the proposed system. In summary, theproposed system is a holistic approach that not only addresses the technical intricacies of retrofitting but also considers environmental, economic, and societal aspects. By aligning with global sustainability goals and leveraging innovative technologies, the proposed system strives to make retrofitted electricTVS XL mopeds a practical, efficient, and widely accepted mode of transportation.

4.3. ELECTRIC CIRCUIT DIAGRAM OF BATTERY CHARGER

In order to utilize the battery to its maximum capacity the battery charger plays acrucial role. The remarkable features of a battery charger are efficiency and reliability, weight and cost, charging time and power density. The characteristicsof the charger depend on the components, switching strategies control algorithms. This control algorithm can be implemented digitally using a microcontroller.

The charger consists of two stages. First, one is the AC-DC converter with powerfactor correction which converts the AC grid voltage into DC ensuring high power factor. The later stage regulates the charging current and voltage of the battery according to the charging method employed.

The charger can be unidirectional i.e. can only charge the EV battery from the grid or bidirectional i.e. can charge the battery from the grid in charging mode and can pump the surplus amount of power of the battery into the grid.

This is lithium-ion battery charger circuit (48v,5A) for 48v,24Ah battery as shown in figure4.2. The circuit given here is a current limited lithium ion battery charger built around the famous variable voltage regulator IC LM 317. The charging current depends on the value of resistor R2. Resistor R3 and R4 determine the charging voltage. Transformer T1 steps down the mains voltage and bridge D1 does the job of rectification. C1 is the filter capacitor. Diode D1 prevents the reverse flow of current from the battery when charger is switched OFF or when mains power is not available.

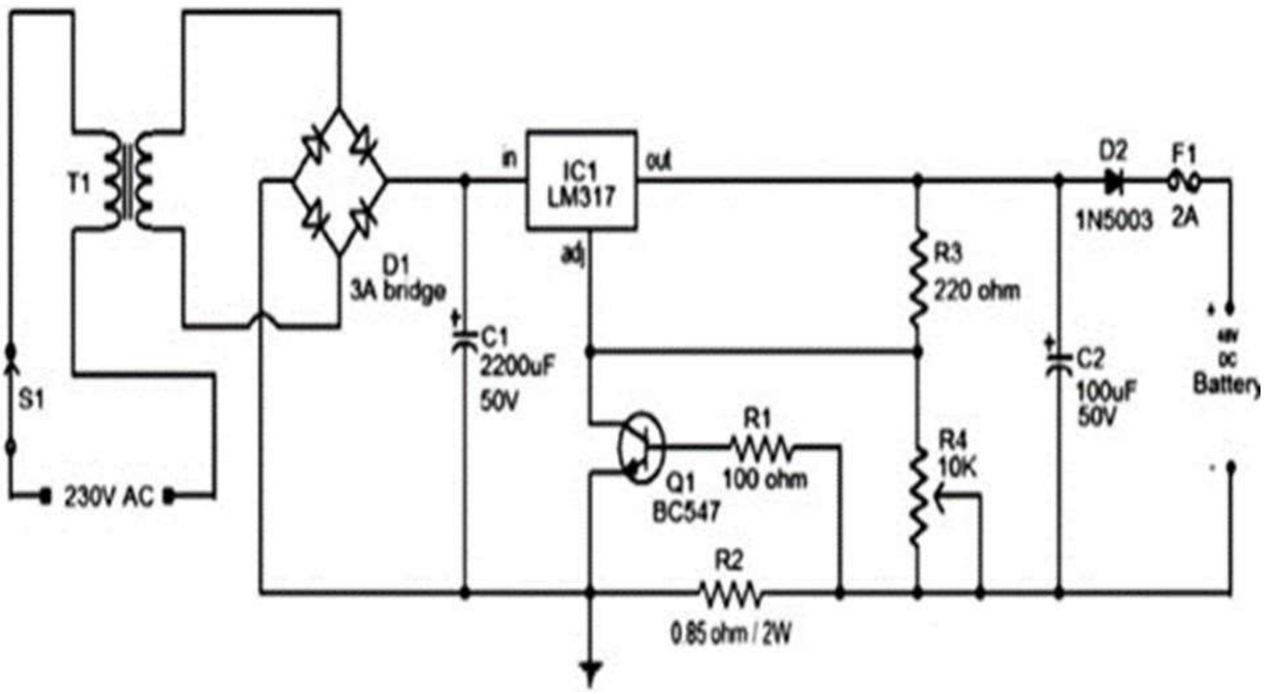

Fig. 4.2 Equivalent of battery charger

4.4 CONVERSION COST

Table 4.1 Operating Cost of ICE TVS XL

Fuel Cost	50km per day, 1500 km per month [Rs 103 /1L] 25L per month Rs2,575 1-year cost Rs30,900 5-year cost Rs1,54,500
Maintenance Charge	1 year / Rs 3000 5year/ Rs15,000
Total cost	5years/ Rs1,69,500

Table 4.2 Electrical Propulsion Kit

Electrical Propulsion Kit	Rs35,000
Charging Cost	50km per day, 1500 km per month 1.25 units (full charge) Rs4-5/1 unit Rs0.25/km Rs4,500/1year Rs22,500/5year
Maintenance	Rs12,500/5year
Old Vehicle rate	Rs.10,000
Total	**Rs 80,000/5years**

Total Saving=Rs89,500/ 5year

CHAPTER 5

SELECTION OF BATTERY SYSTEM

1.1 SELECTION OF MOTOR SYSTEM

For deciding the power rating of vehicle, the vehicle dynamics like rolling resistance, gradient resistance, aerodynamic drag, etc. has to be considered. For illustration procedure for selecting motor rating for an electric TVS XL of gross weight 150 kg is considered.

The force required for driving a vehicle is calculated as:

F(total) = F(rolling) + F(gradient) + F (aerodynamic drag)

Where,

- ✓ F(total) = Total force
- ✓ F(rolling) = Force due to Rolling Resistance
- ✓ F(gradient) = Force due to Gradient Resistance
- ✓ F(aerodynamic drag) = Force due to Aerodynamic Drag
- ✓ F(total) is the total tractive force that the output of the motor must overcome, in order to movie vehicle.

ROLLING RESISTANCE

Rolling resistance is the resistance offered to the vehicle due to the contact of tire with road. The formula for calculating force due to rolling resistance is given by equation.

F(rolling) = C(rr) × M × g

Where, Crr = Coefficient of Rolling Resistance,

M = mass in kg

g = acceleration due to gravity = 9.81 m/s^2

For application consider

Crr = 0.004 as per below table and weight of our TVS XL = 150 kg

Then, F(rolling) = Crr×M×g =0.004×150×9.81= 5.8 N (Newton)

Table 5.1 Coefficient of rolling resistance

C(rr)	Type of area
0.001-0.002	Railroad steel wheels on steel rail
0.001	Bicycle tire on wooden track
0.002	Bicycle tire on concrete
0.004	Bicycle tire on asphalt road
0.008	Bicycle tire on rough paved road
0.006-0.01	Truck tire on asphalt
0.01-0.015	Car tire on concrete, new asphalt, cobbles small new
0.02	Car tire on tar or asphalt
0.02	Car tire on gravel-rolled new
0.03	Car tire on cobbles-large worn

GRADIENT RESISTANCE

Gradient resistor of the vehicle is the resistance offered to the vehicle while

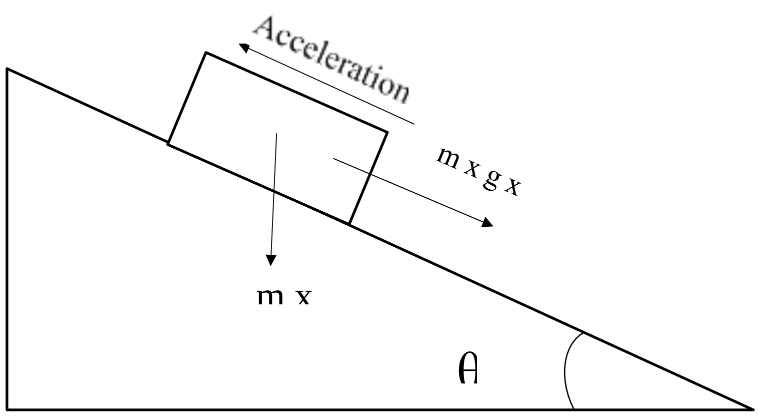

Fig. 5.1 Free Body Diagram of a Vehicle moving up an Inclined surface

climbing a hill or flyover or while travelling in a downward slope. The angle between the ground and slope of the path is represented as θ which is Figure. The formula for calculating the gradient resistor is given by equation below

F (gradient resistance) = $\pm M \times g \times \sin\theta$

Where,

+(positive) sign for motion up the gradient

-(negative) sign for motion down the gradient

For application consider, let us consider electric TVS XL run at an angle of θ (inclined angle) = 2.5°

F (gradient resistance) = $\pm M \times g \times \sin\theta = 150 \times 9.81 \times \sin 2.5^{\circ} = 64.8N$

AERODYNAMIC DRAG

Aerodynamic drag is the resistive force offered due to viscous force acting on a vehicle. It is linearly determined by the shape of vehicle.

Aerodynamic drag is the resistive force offered due to viscous force acting on a vehicle. It is linearly determined by the shape of vehicle.

The formula for calculating aerodynamic drag is given by below equation.

F (aerodynamic drag) = $0.5 \times C_d \times A(f) \times \rho \times v2$

Where,

- ✓ C_d=Drag coefficient,
- ✓ A(f) =Frontal area
- ✓ ρ = Air density in kg/m3,
- ✓ v = velocity in m/s

For application consider, maximum speed of our TVS XL is 35 kmph (given) that is 9.72222 m/s and air density is 1.1644 kg/m3 at 30°

temperature and drag coefficient are 0.5, frontal area is 0.7 as per the table shown below.

Then, F (aerodynamic drag) $= 0.5 \times C_d \times Af \times \rho \times v^2$

$$= 0.5 \times 0.5 \times 0.7 \times 1.1644 \times (9.7)^2$$

$$= 19.16 \text{ N}$$

Table 5.2 C_d=Drag coefficient, A(f) =Frontal area

Vehicle	CD	Af
Motorcycle with rider	0.5-0.7	0.7-0.9
Open convertible	0.5-0.7	1.7-0.9
Limousine	0.22-0.4	1.7-2.0
Coach	0.4-0.8	6-10
Truck without trailer	0.45-0.8	6.0-10.0
Truck with trailer	0.55-1.0	6.0-10.0
Articulated vehicle	0.5-0.9	6.0-10.0

Then, the force required for driving a vehicle is,

F (total) = F(rolling) + F (gradient)+ F (aerodynamic drag)

$$= 5.8+64.8+19.6$$

$$= 90.2 \text{ N}$$

Then, the power required for driving a vehicle is,

Power = Force × Velocity × (1000 ÷ 3600)

= 90.2× 35 × (1000 ÷ 3600)

= 890.66 W

Where,

- ✓ Power in watts
- ✓ Force in Newton
- ✓ Velocity in kmph

Hence, the power required to propel the vehicle is 890.66 W, which is just below our motor specification 900 W. and the design is safe.

5.2. DESIGN OF BATTERY

From motor calculation we get,

Wattage=900W, Voltage=48V So, to find watt.hr = 900W × 1hr =900 Wh

Out of the full battery, 80% should be in use and 20% should be remaining in thiscase

To find the battery watt.hr = 900Wh × 1.20 =1080Wh

Hence, Current (Ah) in the battery =1080Wh ÷ 48V = 22.5Ah

5.3 SELECTION OF BATTERY CHARGER

Suppose we have to charge a battery in 5 hr. So, our required wattage is 1080Wh

According to the above condition,

Wattage of charger = 1080Wh ÷5hr = 216W

Hence, current rating of charger = 216W ÷ 48V = 4.5A

As per the above calculation to charge 48V,24Ah battery in 5 hours we require a 48V, 4.5A charger.

5.4 BATTERY SPECIFICATION

Voltage Rating = 48V, Current Rating = 24Ah

So, Battery Power = Voltage Rating × Current Rating

= 48 × 24

= 1152Wh

5.5 DYNAMIC PERFORMANCE ANALYSIS SOFTWARE

Dynamic performance analysis software uses complex mathematical models to simulate various riding scenarios. It assesses factors like

```
t=linspace(0,50,501); % 0 to 50 s, in 0.1 s steps
vel=zeros(1,501); % 501 readings of velocity
d=zeros(1,501);% Array for storing distance travelled
dT=0.1; % 0.1 second time step
for n=1:500
if vel(n)<10.8 % Torque constant till this point
vel(n+1)= vel(n) + dT*(1.57 - (0.00145*(vel(n)^2)));
elseif vel(n)>=10.8
vel(n+1)=vel(n)+dT*(7.30-(0.53*vel(n))-(0.00145*(vel(n)^2)));
end;
d(n+1)=d(n) + 0.1*vel(n); % Compute distance travelled.
end;
vel=vel.*3.6; % Multiply by 3.6 to convert m/s to kph
plot(t,vel); axis([0 30 0 50]);
xlabel('Time / seconds');
ylabel('Velocity / kph');
title('Full power (WOT) acceleration of TVS XL MOPED')
```

Fig 5.2 Full power acceleration on TVS XL

braking efficiency, and energy consumption. The software provides valuable insights into torque distribution, energy recovery during braking, and overall vehicle dynamics. This data informs adjustments to the electric motor controller for optimal performance.

General Dynamic Equation:

$$vn + 1 = vn + \partial t \times (7.30 - 0.53v - 0.00145v2n)$$

Where:

i. V is a velocity of a vehicle{m/s}

ii. dt is a step time {s}

- ✓ Maximum speed: 45 kph (28mph)
- ✓ 10 m from standing start time: 3.2 second
- ✓ 100 m from standing start time: 12 second

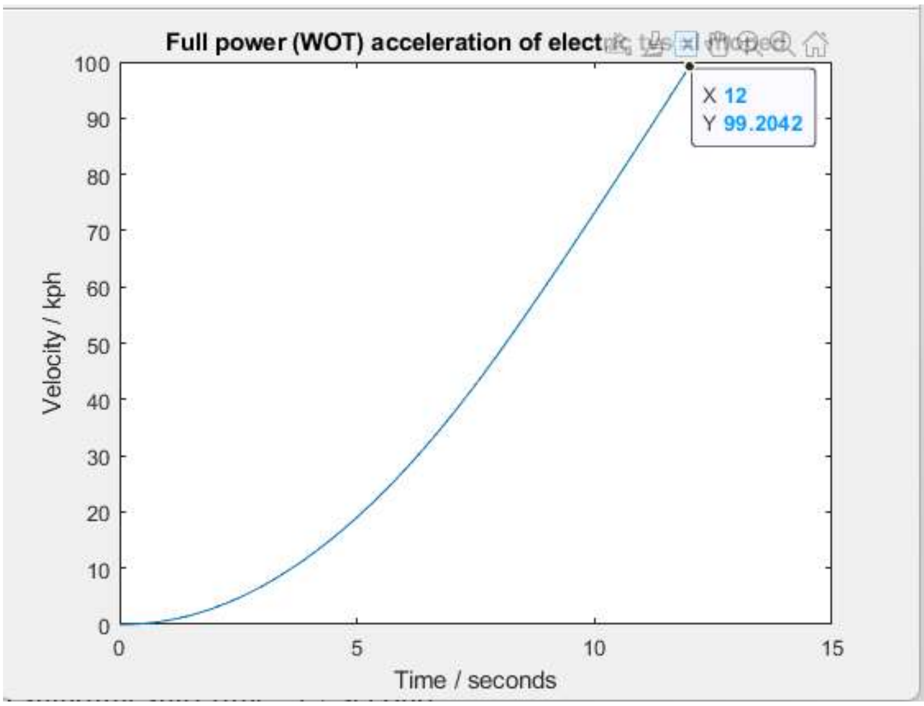

Fig 5.3 Full power acceleration on TVS XL

CHAPTER 6

HARDWARE DESCRIPTION

6.1BATTERY CHARGER

The retrofit electric TVS XL moped is equipped with a high-capacity lithium-ion battery pack. The battery is strategically positioned within the moped to maintain balance and optimize space utilization. The battery's voltage and energy capacity are carefully chosen to provide an optimal balance between range and performance.

- ✓ 48V-24Ah

Advantages

- ✓ High energy density provides an extended range per charge.
- ✓ Lightweight and compact design for optimal space utilization.
- ✓ Long lifespan with low maintenance requirements.

Fig. 6.1 Electric Vehicle Conversion Kit

6.2 CONTROLLER UNIT

A sophisticated electronic controller serves as the central nervous system of the electric moped. This controller, often utilizing advanced microprocessor technology, regulates the power flow from the battery to the brushless DC motor. It manages variables such as speed, torque, and acceleration, ensuring smooth and efficient operation.

- ✓ Rated Voltage – DC/48/60/72V
- ✓ Phase angle - 120°
- ✓ Protect Voltage – 42/52±0.5v

Advantages

- ✓ Precise control over the electric motor's speed and torque.
- ✓ Efficient management of power flow, optimizing energy consumption.
- ✓ Improved acceleration and responsiveness for a smoother ride.
- ✓ Integration with regenerative braking systems for enhanced efficiency.

Fig. 6.2 Controller Unit

6.3 BLDC MOTOR (BRUSHLESS DC MOTOR)

The moped is powered by a Brushless DC motor, known for its efficiency, reliability, and compact design. This motor is integrated into the wheel hub or drivetrain, eliminating the need for a traditional gearbox. The BLDC motor provides instantaneous torque and a quiet, low-maintenance operation.

- ✓ Voltage-48V
- ✓ 0.75HP

Fig. 6.3 BLDC Chain Type Motor

Advantages

- ✓ High efficiency and reliability, reducing energy losses.
- ✓ Compact design eliminates the need for a gearbox, reducing weight.
- ✓ Silent operation enhances rider experience.
- ✓ Instantaneous torque delivery improves overall dynamic performance.

6.4 INDICATORS

The moped features a multifunctional dashboard with LED indicators. These indicators provide real-time information about battery status, charging progress, and system health. Additionally, safety indicators such as turn signals and brake lights contribute to overall rider awareness and road safety.

Advantages

- ✓ Real-time feedback on battery status enhances user awareness.
- ✓ Safety indicators, such as turn signals and brake lights, improve road safety.
- ✓ Multifunctional dashboard provides a comprehensive overview.

6.5 E-BIKE THROTTLE

The electric moped incorporates an electronic throttle system that enables precise control over speed and acceleration. The throttle may be designed as a twist grip or thumb lever, allowing the rider to intuitively modulate the power output from the motor based on riding conditions.

Advantages

- ✓ Intuitive modulation of power output for precise control.
- ✓ Enables seamless acceleration and deceleration.
- ✓ User-friendly design enhances the overall riding experience.
- ✓ Contributes to energy efficiency by optimizing power usage

Fig. 6.4 E-Bike Throttle

6.6 HEADLIGHT

A high-efficiency LED headlight is integrated into the front of the moped. This headlight ensures visibility during low-light conditions, enhancing rider safety. The use of LED technology minimizes energy consumption, contributing to the overall energy efficiency of the electric vehicle.

Advantages

- ✓ High-efficiency LED technology minimizes energy consumption.
- ✓ Ensures visibility during low-light conditions, enhancing safety.
- ✓ Contributes to the overall energy efficiency of the electric moped.
- ✓ Long lifespan and durability compared to traditional lighting.

6.7 FRAME MODIFICATIONS

To accommodate the new electric components seamlessly, specific frame modifications are implemented. These modifications maintain the structural integrity of the moped while ensuring proper placement and support for the electric motor, battery pack, and associated components.

Advantages

- ✓ Maintains the structural integrity of the moped during retrofitting.
- ✓ Allows seamless integration of new electric components.
- ✓ Preserves the original design aesthetics and functionality
- ✓ Ensures safety and stability during the operation of the electric moped.

Fig. 6.5 Frame Modification

Fig. 6.6 Conversion Kit

6.8 WIRING AND CONNECTORS

The retrofitting process includes the installation of a robust wiring system with high-quality connectors. Wiring is organized and secured to minimize the risk of electrical issues. Connectors are selected for durability and reliability, ensuring efficient electrical connectivity between components.

Advantages

- ✓ Robust wiring minimizes the risk of electrical issues.
- ✓ High-quality connectors ensure reliable electrical connectivity.
- ✓ Contributes to the overall efficiency and safety of the electric moped.
- ✓ Simplifies maintenance and troubleshooting processes.

6.9 SAFETY FEATURES

The moped incorporates safety features such as a keyless ignition system, anti-theft mechanisms, and electronic overcurrent protection. These features enhance user safety and the overall security of the electric vehicle.

6.10 SPECIFICATIONS

Table 6.1 Specifications/Rating

Parameters	Specifications/Rating
Type of the Vehicle	Retrofit E-TVS XL
Type of Motor/Drive	BLDC Motor (Chain Type)
Speed (Km/Hr)	45
Input Voltage (V)	48
Input Power (Watts)	750
Battery Capacity (Ah)	24
Charging Time (Hrs)	5
Cost/KMs (Rs)	0.20
Battery Charger	48v, 4.5A

CHAPTER 7

RESULT AND DISCUSSION

In response to the escalating concerns regarding air pollution from conventional fuel-based vehicles, this project delves into the implementation of an eco-friendly retrofit electric TVS XL moped. The focus lies on the integration of sustainable technologies to mitigate environmental impact while maintaining practical usability. The retrofit electric TVS XL moped is powered by a 48V, 25Ah lithium-ion battery, capable of being fully charged within 5 hours using a 48V, 4.5A charger. This charging setup enables the moped to store between 1150 to 1200Wh of energy, facilitating a single-charge range of up to 50 km at an optimal speed range of 35 to 45 kmph. By transitioning to electric power, this moped significantly reduces emissions and contributes to cleaner air quality, promoting a healthier environment for human habitation. Additionally, this project demonstrates significant cost savings compared to an Internal Combustion Engine (ICE) Vehicle. Over a span of five years, the retrofit electric moped offers a cost saving of approximately ₹89,000, factoring in fuel and maintenance expenses.

Fig7.1 Snapchat of EV-XL Moped(a)

The successful implementation of this eco-friendly retrofit underscores the feasibility and efficacy of adopting sustainable transportation solutions in mitigating environmental challenges. This project not only showcases the technical viability of eco-friendly retrofit solutions but also underscores the imperative of transitioning towards sustainable mobility to combat the pressing issue of air pollution. this project demonstrates significant cost savings compared to an Internal Combustion Engine (ICE) Vehicle.

Fig7.2 Controller Unit

Fig7.2 EV-XL Moped(b)

CHAPTER 8

CONCLUSION

The development of a retrofit electric system for the TVS XL moped marks a significant stride towards sustainable and eco-friendly mobility solutions. The project aimed to address key challenges associated with traditional Internal Combustion Engines (ICE), such as environmental impact, rising fuel costs, and the reluctance of consumers, particularly farmers, to adopt new electric vehicles. The following conclusions can bedrawn from the successful execution of this project: The retrofitting approach proved to be a cost-effective solution for transforming the conventional TVS XL moped into an electric-powered vehicle. By replacing the IC Engine with an electric motor and optimizing power transmission, the project demonstrated a viable alternative to expensive new electric bike purchases. The emphasis on using existing spares and maintaining the original design played a crucial role in the project's success. This approach not only preserved the structural integrity of the moped but also utilized spare parts effectively, minimizing the overall cost of the retrofitting process. The implementation of charging optimization software contributed to the efficiency of the electric moped. By reducing charging times and analyzing cost-effective charging strategies, the project addressed concerns related to the practicality and affordability of electric vehicles, making them more accessible to a wider audience. The dynamic performance analysis software played a pivotal role in optimizing the electric moped's performance. Through simulations and analyses, the project fine-tuned torque distribution, energy recovery during braking, and overall maneuverability. This resulted in an electric moped that not only meets but potentially exceeds the performance of its traditional counterpart. The core objective of creating a green, pollution-free environment was achieved through the successful retrofitting of the TVS XL moped. The integration of electric components, eco-friendly driving features, and the reduction of emissions contribute to a more sustainable and environmentally conscious mode of transportation. The incorporation of user interface software enhanced the overall user experience by providing riders with real-time information on battery status, charging progress, and performance analytics. This user-friendly interface contributes to the adoption of electric mobility by making it more accessible and convenient. The success of this retrofit project opens avenues for similar initiatives in the future. The modular and adaptable nature of the retrofitting approach allows for scalability and applicability to other models or vehicle types. As electric mobility gains momentum, this project serves as a blueprint for transforming existing gasoline vehicles into sustainable electric alternatives. In conclusion, the development of the retrofit electric TVS XL moped presents a holistic solution to the challenges posed by traditional IC engines. It not only showcases the technical feasibility of such conversions but also addresses economic and environmental concerns. This project contributes to the ongoing evolution of the automotive industry towards sustainable and energy-efficient transportation solutions.

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