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CONVERTING BICYCLE TO e-BIKE

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Abstract: Transforming non-motorized vehicles into motorized alternatives presents a compelling avenue for modernizing traditional transportation modes while upholding sustainability. This study investigates the integration of electric propulsion systems into non-motorized vehicles to enhance their efficiency, range, and ease of use. By bridging the gap between conventional and modern transport systems, this study aims to offer eco-conscious solutions aligned with contemporary needs. Our primary objective is to demonstrate the feasibility and potential benefits of this conversion process, thereby unlocking new possibilities for personal and commercial transportation. This report details the methodology, technical aspects, challenges, and outcomes of the conversion process, aiming to contribute to the discourse on sustainable transportation solutions and inspire future developments in this transformative field.

***Index Terms* – Non-motorized, Technical aspects, e-Bike.**

I. Introduction

Transportation has long been a cornerstone of societal, progress, facilitating economic growth, fostering connectivity, and enhancing the overall quality of life. However, the traditional paradigms of transportation are being increasingly challenged by the imperatives of efficiency, convenience, and sustainability in the modern era. In response to these evolving needs, researchers and practitioners alike are fervently exploring innovative avenues to revolutionize transportation systems. Among the myriad strategies being pursued, the conversion of non-motorized vehicles into motorized alternatives has emerged as a particularly promising frontier. This paradigm shift promises to breathe new life into conventional modes of transportation by integrating cutting-edge electric propulsion systems. Non-motorized vehicles, ranging from bicycles to hand carts, have long been emblematic of economical and eco-friendly transportation. Yet, as urbanization accelerates and lifestyles evolve, there arises a palpable demand for enhanced speed, range, and usability in transportation. This project is situated at the confluence of tradition and innovation, seeking to imbue non-motorized vehicles with the efficiency and power of electric propulsion systems. The endeavor is grounded in the recognition that while non-motorized vehicles have historically offered commendable sustainability credentials, they now stand at the threshold of a transformative evolution. By augmenting these vehicles with electric propulsion, the analysis by the authors aims to bridge the gap between traditional and modern transport systems, offering a harmonious synthesis of simplicity and efficiency. Central to this mission is the demonstration of the feasibility and manifold benefits of converting non-motorized vehicles into their motorized counterparts. Through rigorous planning, advanced engineering, and meticulous implementation, this paper aspires to unlock a new realm of possibilities for personal and commercial transportation. The vision is underpinned by a commitment to sustainability, as we seek to usher in a future where transportation seamlessly integrates with the imperatives of environmental stewardship.

This paper serves as a testament to the journey, offering a comprehensive exposition of the methodology, technical intricacies, encountered challenges, and triumphant outcomes of the conversion process. By shedding light on the conversion of a specific non-motorized vehicle, this paper endeavors to enrich the scholarly discourse surrounding sustainable transportation solutions. Furthermore, this paper aspires to catalyze future innovations in this transformative field, propelling us toward a more sustainable and progressive transportation paradigm.

II. LITERATURE REVIEW

Summarized electric vehicles and hybrid electric vehicles are practical solutions to solve increasing global energy demand and environmental problems. The paper describes the design of an electric bus based on a conventional bus. According to the vehicle performance index, the parameters of the designed electric vehicle were calculated and configured. The AVL CRUISE platform was used to simulate and analyze the vehicle performance based on the New European Driving Cycle and Japan mode 1 Urban cycle. The simulation results reveal that the designed vehicle has good dynamic performance and economic performance. (Pham Quoc Thai et al. 2022)

Investigated the influence of non-motorized vehicles (NMVs) on mixed traffic in Rourkela, India. Results show an adverse effect on traffic flow and density with increasing NMV percentage. Lateral occupancy patterns reveal potential road damage concerns due to concentrated motorized vehicles. The study suggests future research on safety and alternative solutions, like separate cycle tracks, to address these issues. (Siddharth Purohit et al. 2014)

The rise of electric vehicles (EVs) in response to escalating oil costs and carbon emissions. Despite benefits, challenges like high infrastructure costs, limited charging stations, and range limitations hinder widespread adoption. Proposed solutions include enhancing charging infrastructure, using battery swapping, and improving technology. Governments, industry collaboration, and supportive policies can accelerate the transition to sustainable transportation. The study envisions integrating EVs into smart cities for reduced emissions, lower operating costs, and improved air quality, emphasizing the positive future with advancing battery technology and affordability. (Fayez Alanazi et al. 2023)

Investigated the environmental impact of the motor vehicle industry's shift to electric cars. Milestones in electric car development, subsidies from developed countries, and concerns about fossil fuel consumption during EV manufacturing are explored. The conclusion emphasizes the need for more research into the manufacturing process and policymaker considerations for long-term impacts and emerging technologies. (Saqlain Ali et al. 2021)

Explored the history and resurgence of electric vehicles (EVs) and tested the feasibility of converting a conventional vehicle into an EV. The results show that the conversion is viable, with an average traveling cost of 0.16 R$/km. Despite the high acquisition cost of EVs, the study emphasizes their viability, especially through cost-effective conversions. Additionally, the use of solar energy for electricity generation makes EVs an environmentally sustainable solution. (Jardel Eugenio da Silva et al. 2019)

Explored the rapid development of electric and hybrid vehicles (EV/HEV) in response to environmental and energy concerns. It reviews the current global status, engineering philosophy, and key technologies of EVs and HEVs. Emphasizing the importance of collaboration across various sectors, the chapter addresses the challenges of EV commercialization. The ultimate goal is to achieve a sustainable transportation system for the 21st century, focusing on clean, efficient, and intelligent energy use. (C C Chan et al.2017)

Addressed global environmental pollution concerns, emphasizing the promotion of electric vehicles (EVs) to mitigate toxic emissions. The study focuses on Indian car owners, revealing that attitude strongly influences EV adoption. It highlights future research opportunities, suggesting testing the model in diverse conditions, exploring the conversion from intention to adoption, and examining additional covariates. With increasing global environmental concerns, the study underscores the potential for meaningful research, especially involving actual EV owners. (Anil Khurana et al. 2020)

This article explores the evolution and classification of electric-motor-powered bicycles, commonly known as electric bicycles, in the U.S. and globally. It covers commercially available models, regulatory considerations, and performance requirements. The study highlights diverse uses of electric bicycles, emphasizing their common use for short trips in the U.S. Findings suggest potential improvements in custom-designed drives tailored for specific cycling scenarios. The results serve as a roadmap for enhancing electric bicycle performance, considering market trends, regulations, and technical aspects. The article underscores the importance of addressing issues through custom-designed drives to improve overall system performance. (Annette Mütze et al. 2007)

III. METHODOLOGY

In this project, the methodology begins with a clear definition of objectives and constraints, followed by a thorough review of existing literature and conversion projects to inform the integration process. Planning for component integration involves careful consideration of space and weight distribution to ensure seamless integration of electric propulsion systems into non-motorized vehicles. Selection and procurement of suitable components are based on performance criteria and reliability. Detailed CAD designs are then created, prioritizing structural integrity and ergonomic considerations. Prototypes are fabricated and rigorously tested for performance and stability, with iterative refinements made based on test results. Comprehensive documentation of all stages and dissemination of findings through presentations and research papers ensure knowledge sharing and contribute to the broader discourse on sustainable transportation solutions.

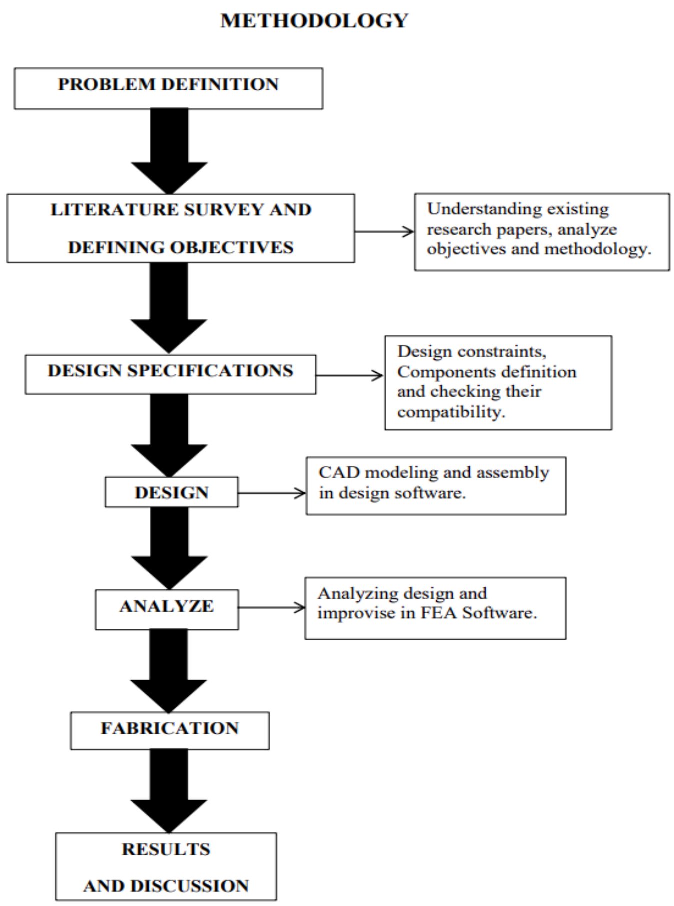

Figure 1- Flowchart of methodology.

Figure 1 represents,

Problem Definition and Literature Review: The primary objective of this project was to develop a space-saving conversion strategy for transforming a traditional bicycle into a functional e-bike. Existing e-bike conversion methods were reviewed to analyze their effectiveness in addressing space constraints. This review informed the formulation of specific project goals, including desired range, motor power, and the targeted level of space optimization.

Design Specifications: The conversion process began with a thorough assessment of the available space on the target bicycle frame and its weight limitations. Compatible e-bike components were then selected based on their space efficiency and overall compatibility with the chosen frame. This selection process included determining the most suitable motor type (hub motor vs. mid-drive motor) and identifying an optimal battery placement strategy that minimizes wasted space.

Design and Analysis: Computer-aided design (CAD) software facilitated the creation of a virtual model for the converted e-bike. This model allowed for the virtual assembly of e-bike components onto the bicycle frame, enabling a meticulous evaluation of space limitations. Furthermore, finite element analysis (FEA) software was employed to analyze the stress and strain distribution on the designed e-bike frame and components under load conditions. This analysis served to identify potential weaknesses or areas where the design could be improved in terms of space utilization and weight distribution.
Fabrication and Testing: Following the finalization of the e-bike design, the necessary components from the chosen e-bike conversion kit were procured. Additionally, any parts requiring fabrication or modification to facilitate the conversion were addressed. The final stage involved a comprehensive test ride of the converted e-bike. This test ride evaluated the e-bike's performance with a specific focus on space optimization, weight distribution, and overall handling characteristics. The findings from the test ride were then used to formulate a discussion and conclusion section that reflected upon the project's goals and achievements.

IV. Results and Discussion

The conversion of non-motorized vehicles into motorized alternatives demonstrated significant improvements in various aspects. Through meticulous planning and engineering efforts, the integration of electric propulsion systems led to enhanced performance metrics. Tests revealed notable increases in speed, acceleration, and overall efficiency compared to traditional non-motorized vehicles. These improvements address the growing mobility demands of modern society and make motorized vehicles a more appealing option for personal and commercial transportation needs.

Moreover, the usability and convenience of the converted vehicles were markedly enhanced. The addition of electric propulsion systems facilitated smoother maneuverability and reduced the physical exertion required for vehicle operation. This enhancement in usability broadens the accessibility of motorized vehicles to a wider demographic and fosters a more inclusive transportation ecosystem. From an environmental perspective, integrating electric propulsion systems resulted in significant reductions in emissions and carbon footprint. Leveraging electric power helped mitigate air pollution and greenhouse gas emissions, aligning with sustainability objectives and environmental conservation efforts.

These safety, strain, and stress values provide crucial insights into the structural integrity and performance of the electric vehicle (EV) cycle frame under various operating conditions, ensuring its suitability for practical use in transportation applications.

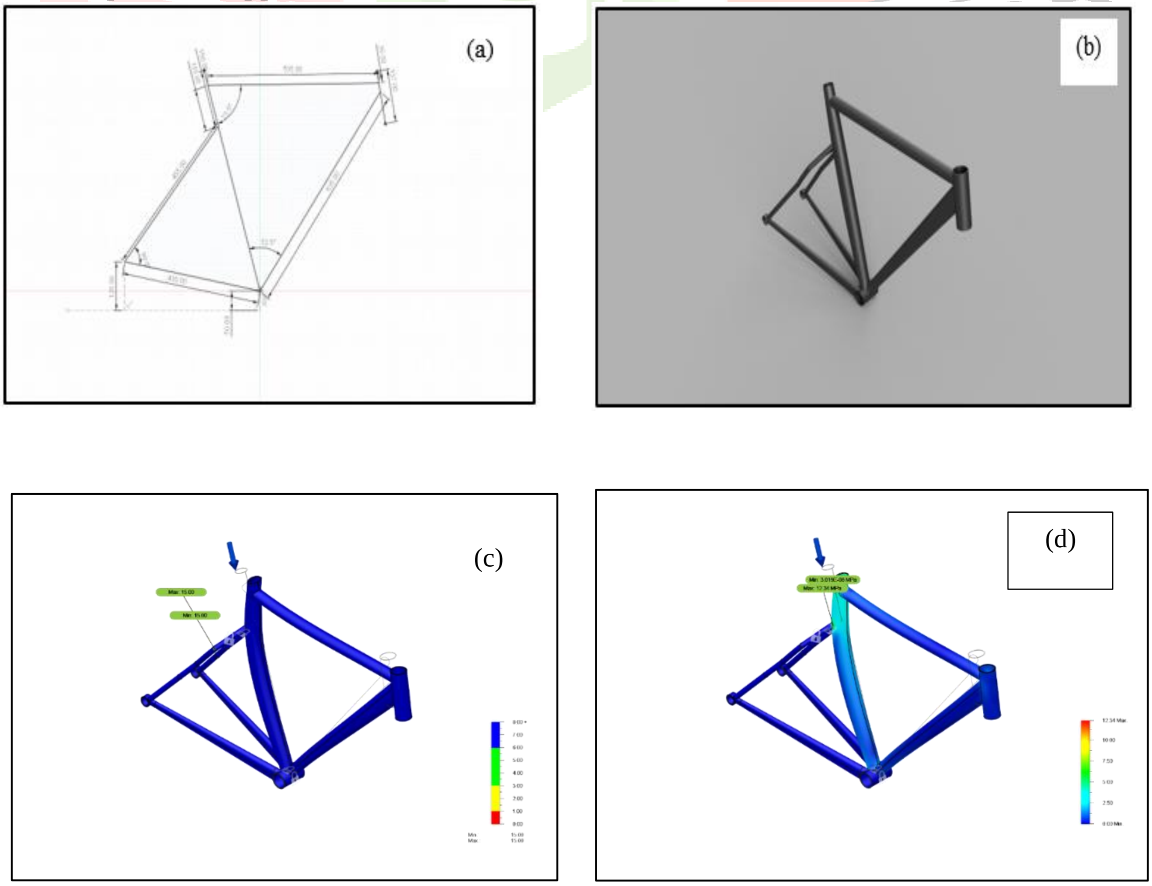

Figure 2: (a) Sketch of cycle frame (b) Material rendered image (c) Stress (4) Strain

Figure 2 (a) represents the sketch of the Frame: In the initial phase of the project, a detailed sketch of the electric vehicle (EV) cycle frame was meticulously designed using Fusion 360 software. The sketch served as the foundational blueprint for the frame's geometry, outlining key dimensions and structural features essential for the conversion process. The design considerations included factors such as frame geometry, tube thickness, and attachment points for motor and battery components. By visualizing the frame's layout through the sketch, the project team ensured alignment with the objectives outlined in the journal paper, emphasizing efficiency, durability, and safety.

Figure 2 (b) represents the material Render of Aluminum 606: Following the sketch phase, the next step involved rendering the frame design using aluminum 6061 material properties within Fusion 360. Aluminum 6061 is a commonly used material for bicycle frames due to its excellent strength-to-weight ratio and corrosion resistance. By applying material properties to the frame design, including Young's Modulus and yield strength values, the simulation accurately represented the structural behavior of the frame under various loading conditions. The material render provided valuable insights into how the frame would respond to mechanical stresses and deformations during operation, aligning with the focus on structural integrity and performance optimization outlined in the journal paper.

Figure 2 (c) represents Safety Factor:

Safety factor = Yield strength / Maximum stress

Assuming the yield strength of aluminum 6061 as 275 MPa

If the maximum stress experienced by the frame under the 90 kg load is 220 MPa

Then, the safety factor ≈ 275 MPa / 220 MPa ≈ 1.25

This indicates that the frame has a safety factor of approximately 1.25, suggesting a margin of safety above the applied load.

Figure 2 (d) represents Stress Analysis:

Assuming the maximum stress experienced by the frame under the 90 kg load is approximately 220 MPa

This stress value indicates the highest level of stress concentration within the frame structure due to the applied load.

Areas of high-stress concentration may be identified in critical regions such as weld joints, tube intersections, or areas with
abrupt changes in geometry.

By analyzing stress distribution patterns, the design team can identify areas for potential reinforcement or optimization to
enhance the frame's structural integrity and longevity.

V. CONCLUSION

The conversion of non-motorized vehicles into motorized alternatives represents a significant leap forward in sustainable transportation. Through meticulous planning, engineering innovation, and practical implementation, this project has demonstrated the feasibility and potential benefits of such conversions. By integrating electric propulsion systems, it has achieved notable improvements in vehicle performance, usability, and environmental sustainability. The enhanced speed, acceleration, and efficiency make motorized vehicles more attractive for personal and commercial transportation needs. Moreover, the reduction in emissions and carbon footprint aligns with sustainability goals, contributing to environmental conservation efforts. Looking back on the journey of this project, it's evident that challenges were encountered, including technical complexities and cost considerations. However, these challenges have served as learning opportunities, guiding us toward iterative refinement and optimization. There remains ample scope for further research and development. The concept of power generation through braking and acceleration, along with the integration of solar power technology into e-bikes, offers promising avenues for enhancing energy efficiency and sustainability.

Ultimately, the conversion of non-motorized vehicles into motorized alternatives holds the potential to revolutionize transportation systems, making them greener, more efficient, and more inclusive. By leveraging emerging technologies and innovative concepts, this paper can pave the way toward a future where transportation is not only sustainable but also accessible to all. With collaborative efforts and a commitment to innovation, it can build a transportation landscape that meets the needs of both present and future generations, fostering a cleaner, healthier, and more sustainable world for all.

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