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CONVERSION OF IC ENGINE TWO-WHEELER TO ELECTRIC BIKE

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Abstract:

The design and implementation of an electric bike (e-bike) conversion system, aimed at transforming a conventional bike into an electric-powered vehicle. The motivation for this project is the increasing demand for eco-friendly, cost-effective, and efficient modes of transportation, particularly in urban areas where traffic congestion and environmental concerns are prevalent. The conversion includes a battery, motor, controller, and throttle mechanism, which are integrated seamlessly into the bike framework to preserve its original structure while providing additional electric power.It involves selecting an appropriate motor and battery to achieve optimal performance while balancing range, power, and weight. The electrical and mechanical integration will be designed to ensure safety, reliability, and easy to use. Further testing, this project will evaluate parameters such as range, speed, and efficiency on the e-bike's performance. Ultimately, this e-bike conversion system provides a sustainable alternative to fossil-fuel-dependent vehicles, offering a practical solution to reduce carbon emissions and promote green transportation.

Keywords: dc–dc converter, 10 inch BLDC Drum, electric vehicle, Micro controller, battery charging, Li ion battery.

1.INTRODUCTION

Internal combustion (IC) engine conversion is the process of modifying an existing IC engine to operate on an alternative fuel or power source. This transformation can be driven by various factors, including environmental concerns, regulatory compliance, fuel efficiency improvements, and cost-effectiveness. With the global push towards sustainable energy solutions, IC engine conversions have gained significant attention as an interim step toward reducing emissions while utilizing existing engine technology.Common IC engine conversions include switching from gasoline to compressed natural gas (CNG), liquefied petroleum gas (LPG), hydrogen, ethanol, or biodiesel.Additionally, some conversions aim to hybridize engines, incorporating electric motors to enhance efficiency. The process typically involves modifications to the fuel system, ignition system, and engine control unit (ECU) to ensure compatibility with the new fuel type.

The conversion of an internal combustion (IC) engine vehicle to an electric vehicle (EV) is an innovative and sustainable approach to modern transportation. With growing environmental concerns, fluctuating fuel prices, and advancements in battery technology, many individuals and businesses are opting to retrofit existing gasoline or diesel-powered vehicles with electric drivetrains. This process involves removing the engine, fuel system, and exhaust components and replacing them with an electric motor, battery pack, motor controller, and other essential systems. The choice of motor type, battery capacity, and power management system plays a crucial role in determining the efficiency, range, and overall performance of the converted vehicle. While electric conversions provide significant benefits such as lower operating costs, zero tailpipe emissions, and reduced maintenance, they also come with challenges, including battery range limitations, charging infrastructure availability, and initial conversion costs. Proper engineering and integration are required to ensure compatibility with the vehicle's existing transmission, braking, and suspension systems. Despite these challenges, IC engine to electric conversions offer a practical and environmentally friendly alternative for vehicle owners, classic car enthusiasts, and fleet operators looking to reduce their carbon footprint and embrace sustainable mobility.Despite the numerous benefits, converting an IC engine vehicle to electric does come with challenges. The initial investment can be high due to the cost of batteries and specialized components, and the conversion process requires technical expertise to ensure safe and efficient operation. Additionally, the vehicle's existing transmission system may need to be modified or removed entirely, depending on the design of the electric motor setup. Charging infrastructure and battery range limitations are also important considerations, especially for long-distance travel. However, with advancements in battery technology, fast-charging networks, and improved energy management systems, electric conversions are becoming more accessible and viable.

Overall, IC engine to electric conversions provide a bridge between traditional gasoline-powered transportation and a fully electrified future. They allow vehicle owners to retain the structural integrity and design of their existing vehicles while benefiting from the advantages of electric mobility. Whether for classic car restorations, commercial fleet upgrades, or personal vehicles, EV conversions are a forward-thinking solution that supports sustainability, energy efficiency, and the long-term reduction of carbon emissions.

With the rising cost of fossil fuels and stricter emissions regulations, converting existing IC engine vehicles to electric has become an attractive option for many vehicle owners. Electric motors are significantly more efficient than combustion engines, converting over 90% of electrical energy into motion, compared to about 30% efficiency in gasoline and diesel engines. Additionally, EVs have fewer moving parts, leading to lower maintenance costs and increased reliability. By converting an existing vehicle rather than purchasing a new EV, owners can retain the structural integrity and sentimental value of their car while reducing waste and environmental impact. Furthermore, electric conversions can provide a solution for vintage and classic car enthusiasts who want to preserve the aesthetics of older vehicles while upgrading their drivetrains to modern electric power.
A Battery Management System (BMS) is essential for monitoring and protecting the battery pack. It ensures optimal performance by preventing overcharging, over-discharging, and overheating. The BMS also balances the cells within the battery pack to maintain efficiency and prolong battery life.

Despite the benefits, converting an IC engine vehicle to an EV presents several challenges. The initial cost of conversion, primarily due to battery and motor expenses, can be significant. However, long-term savings on fuel and maintenance can offset these costs. The weight and placement of battery packs must be carefully managed to ensure proper vehicle balance and performance. Additionally, compatibility with existing vehicle systems, such as brakes and suspension, must be evaluated to handle the new powertrain's requirements. Another key consideration is charging infrastructure, as converted EVs need access to reliable charging stations, particularly for long-distance travel.

IC engine to electric conversions provide a practical and sustainable solution for transitioning to cleaner transportation while maximizing the utility of existing vehicles. With advancements in battery technology, motor efficiency, and charging infrastructure, EV conversions are becoming more viable and accessible. Whether for reducing environmental impact, preserving classic cars, or improving vehicle efficiency, converting an IC engine vehicle to electric represents a forward-thinking approach to modern mobility. This document will further explore the conversion process in detail, including component selection, step-by-step procedures, cost analysis, and real-world applications of electric vehicle conversions.

2. LITERATURE SURVEY

Nikolaus Otto (1832–1891) – The Four-Stroke Engine (1876)

Nikolaus Otto is credited with inventing the four-stroke Otto cycle engine in 1876. His engine used a compression stroke before ignition, which drastically improved fuel efficiency compared to earlier atmospheric engines. This invention became the foundation for most gasoline engines used today in automobiles, motorcycles, and small machinery. Otto's work laid the groundwork for modern IC engine thermodynamics, and his design continues to be widely used.

Rudolf Diesel (1858–1913) – The Diesel Engine (1892)

Rudolf Diesel introduced the compression ignition (CI) engine in 1892, commonly known as the diesel engine. Unlike Otto's engine, which relied on spark ignition, Diesel's engine compressed air to a high temperature, causing the injected fuel to ignite spontaneously. This design significantly improved thermal efficiency, making diesel engines the preferred choice for heavy-duty applications, including trucks, ships, and power generators.

Sir Harry Ricardo (1885–1974) – Combustion Research and Knock Reduction (1923)

Harry Ricardo was instrumental in addressing engine knocking, a phenomenon that reduces efficiency and causes damage to engines. His research in the 1920s and 1930s led to improvements in fuel injection systems, combustion chamber design, and fuel quality. His book The High-Speed Internal Combustion Engine (1923) remains an essential reference for IC engine development.

Charles Fayette Taylor (1894–1996) – Thermodynamics and Engine Performance (1961)

Charles Taylor, a professor at MIT, made significant contributions to IC engine thermodynamics. His book The Internal-Combustion Engine in Theory and Practice (published in 1961) provided a comprehensive analysis of fuel behavior, heat transfer, and efficiency improvements.Taylor's work remains fundamental to engine design and optimization.

John B. Heywood (born 1936) – Internal Combustion Engine Fundamentals (1988)

John Heywood, a leading researcher at MIT, published Internal Combustion Engine Fundamentals in 1988, which became one of the most widely used textbooks in IC engine research. His work focuses on combustion modeling, emissions control, and fuel efficiency improvements. Heywood's research has influenced engine manufacturers in optimizing performance while reducing environmental impact.

Richard Stone (born 1947) – Alternative Fuels and Modern Engine Technologies (1985)

Richard Stone, a professor and researcher in IC engines, explored alternative fuels, hybrid engine technology, and fuel injection systems. His book Introduction to Internal Combustion Engines (first published in 1985) provides in-depth knowledge of modern engine advancements, particularly electronic fuel injection (EFI), variable valve timing (VVT), and turbocharging.

K. A. Subramanian (born 1969) – Biofuels and Hydrogen-Powered Engines (2000s–2010s)

K. A. Subramanian, a researcher at IIT Delhi, has conducted extensive research on biofuels, hydrogen engines, and sustainable fuel alternatives. His studies focus on reducing dependence on fossil fuels by using ethanol, biodiesel, and hydrogen as alternative energy sources. His work in the 2000s and 2010s has contributed to the growing interest in renewable fuels for IC engines.

Lucien Koopmans (born 1972) – Advanced Combustion Techniques (2010s)

Lucien Koopmans from Chalmers University, Sweden, has worked on Homogeneous Charge Compression Ignition (HCCI), an advanced combustion technique that reduces NOx emissions while maintaining high efficiency. His research in the 2010s has helped improve low-emission engine technology, making IC engines more environmentally friendly.

Christopher Rutland (born 1965) – Computational Fluid Dynamics (CFD) for Engine Simulations (1990s–2000s)

Christopher Rutland from the University of Wisconsin-Madison has been a pioneer in using computational fluid dynamics (CFD) to model engine combustion, fuel injection, and airflow dynamics. His work in the 1990s and 2000shas significantly improved engine design, optimization, and emissions reduction.

Zhao Fuquan (born 1970s) – Hybridization and Efficiency Enhancement (2010s–2020s)

Zhao Fuquan, a leading researcher at Tsinghua University, China, has focused on hybrid IC engines, electrification, and fuel efficiency enhancement. His work in the 2010s and 2020s explores how **IC** engines can work in combination with electric motors to reduce fuel consumption and emissions.

Étienne Lenoir (1822–1900) – The First Practical Internal Combustion Engine (1860)

Étienne Lenoir developed the first commercially successful internal combustion engine in 1860. His engine used a gas-air mixture ignited by an electric spark, though it was inefficient. His work paved the way for later improvements by Otto and Diesel.

Nikolaus Otto (1832–1891) – The Four-Stroke Otto Cycle Engine (1876)

Nikolaus Otto's four-stroke Otto cycle engine in 1876 revolutionized engine technology. His design significantly improved efficiency by compressing the air-fuel mixture before combustion. Otto's work laid the foundation for modern gasoline engines.

Rudolf Diesel (1858–1913) – The Compression-Ignition Engine (1892)

Rudolf Diesel developed the diesel engine in 1892, which used compression ignition (CI) instead of spark ignition. His design achieved higher efficiency compared to gasoline engines, making it ideal for heavy-duty applications such as trucks, ships, and industrial power plants.

Dugald Clerk (1854–1932) – The Two-Stroke Engine (1881)

Dugald Clerk is credited with developing the two-stroke engine in 1881. This design improved power output by eliminating the separate intake and exhaust strokes, making it suitable for motorcycles and small machinery.

Charles Kettering (1876–1958) – High-Performance Gasoline Engines (1910s–1920s)

Charles Kettering contributed significantly to high-compression gasoline engines and lead-based fuel additives to prevent knocking. His innovations improved engine efficiency and paved the way for high-performance automotive engines.

3. PROPOSED METHODOLOGY

The proposed system introduces for enhancing internal combustion (IC) engines focuses on improving fuel efficiency, reducing emissions, and integrating alternative fuels through a combination of computational modeling, experimental analysis, and real-world validation. The study begins with a comprehensive literature review to understand the limitations of conventional IC engines, identify key challenges such as incomplete combustion, high fuel consumption, and excessive emissions, and explore emerging solutions such as homogeneous charge compression ignition (HCCI), reactivity-controlled compression ignition (RCCI), and hybrid-electric engine systems. A detailed assessment of previous research, advancements in combustion technology, and alternative fuel applications will be conducted to establish the foundation for this study.

Following the literature review, computational modeling and simulation techniques will be employed to analyze various engine performance parameters and optimize combustion efficiency. Using software tools such as ANSYS Fluent, CONVERGE CFD, and MATLAB-Simulink, simulations will be performed to study air-fuel mixing, combustion behavior, and heat transfer processes under different operating conditions. These simulations will help identify the optimal configurations for improving thermal efficiency and reducing pollutant emissions, such as optimizing the compression ratio, fuel injection timing, and ignition delay. Computational methods will also facilitate the design of new combustion chamber geometries and assess the effects of advanced fuel injection strategies, including direct injection, multiple injection pulses, and stratified charge combustion.

After computational analysis, an experimental setup will be developed to validate the simulation results. A single-cylinder or multi-cylinder test engine will be modified with advanced features such as electronically controlled fuel injection, turbocharging, variable valve timing (VVT), and exhaust gas recirculation (EGR). The experimental phase will involve testing the engine under controlled laboratory conditions using a variety of fuels, including conventional gasoline and diesel, as well as alternative fuels such as ethanol, biodiesel, hydrogen, and synthetic fuels. Real-time data acquisition systems, including pressure sensors, exhaust gas analyzers, and thermocouples, will be used to monitor engine performance metrics such as combustion pressure, fuel consumption, thermal efficiency, and emissions levels. The collected data will be analyzed to determine the impact of various fuel types and engine modifications on performance and emissions reduction.

To further enhance fuel economy and engine efficiency, hybridization strategies will be explored. The integration of an internal combustion engine with electric motors in a hybrid powertrain will be investigated to determine its impact on fuel consumption and emission reduction. Additionally, waste heat recovery technologies such as thermoelectric generators and turbo compounding will be studied to harness excess heat from the exhaust and convert it into usable energy. This phase of the study aims to improve overall energy utilization and maximize the efficiency of IC engines.

In the next stage, artificial intelligence (AI) and machine learning techniques will be applied for real-time optimization of engine performance. AI-based control algorithms, including neural networks, genetic algorithms, and reinforcement learning, will be developed to dynamically adjust engine parameters such as air-fuel ratio, ignition timing, and fuel injection strategies based on varying load and environmental conditions. By leveraging machine learning models, the engine's control system will be trained to predict and adapt to different operating scenarios, ensuring optimal performance while minimizing emissions.

Emission control and environmental impact assessment will form a critical part of the proposed methodology. Advanced after-treatment technologies, including selective catalytic reduction (SCR), diesel particulate filters (DPF), and exhaust gas recirculation (EGR), will be evaluated for their effectiveness in reducing NOx, CO_2, and particulate matter emissions. The study will also assess the feasibility of low-carbon and zero-carbon fuels such as hydrogen and synthetic fuels in internal combustion engines, with a focus on achieving compliance with stringent emission standards such as Euro 6 and Bharat Stage VI (BS-VI). A comparative analysis will be conducted to determine the most efficient and cost-effective method for meeting emission regulations while maintaining engine performance.

A techno-economic analysis will also be performed to assess the cost-effectiveness and commercial viability of the proposed modifications. Factors such as fuel cost savings, initial investment in new technologies, long-term maintenance costs, and environmental benefits will be considered. Additionally, a lifecycle assessment (LCA) will be conducted to evaluate the long-term sustainability of the proposed solutions, including their impact on greenhouse gas emissions and energy consumption. This phase of the study will provide a holistic view of the economic and environmental feasibility of adopting new IC engine technologies.

Finally, real-world validation of the proposed methodologies will be carried out by testing the optimized engine under actual operating conditions. Field trials will be conducted on vehicles and industrial engines to assess performance parameters such as fuel efficiency, power output, durability, and emissions in real-world scenarios. The results will be compared with conventional IC engines to determine the effectiveness of the proposed improvements. The final analysis will summarize key findings and provide recommendations for large-scale implementation of the optimized IC engine technology in transportation, power generation, and industrial applications.

Through this structured approach, the study aims to provide innovative solutions for enhancing the efficiency, sustainability, and environmental friendliness of internal combustion engines. By integrating computational modeling, experimental validation, hybridization, AI-driven optimization, and emissions control strategies, the proposed methodology ensures a comprehensive framework for the development of next-generation IC engines that meet the challenges of modern energy and environmental demands.

4. EXPERIMENTAL ANALYSIS

The experimental analysis aims to validate the findings from computational modeling and assess the real-world performance of internal combustion (IC) engine modifications under controlled laboratory conditions. The process begins with the setup of a test engine on a dynamometer-equipped test bench, where a single-cylinder or multi-cylinder engine is fitted with advanced sensors and

data acquisition systems to monitor key performance parameters in real time. The test bench includes a dynamometer for measuring power output and efficiency, a fuel flow meter for precise fuel consumption analysis, and exhaust gas analyzers for emissions assessment. Additionally, an electronically controlled engine management system is integrated to enable precise adjustments in parameters such as fuel injection timing, ignition timing, and air-fuel ratio.

A crucial aspect of the experimental analysis is fuel testing, where conventional fuels like gasoline and diesel are compared with alternative fuels such as ethanol, biodiesel, hydrogen, compressed natural gas (CNG), and synthetic fuels. Each fuel is tested under different engine loads and speeds to analyze its impact on thermal efficiency, brake power, torque, and combustion stability. The combustion process is examined in detail using in-cylinder pressure sensors, which record real-time variations in combustion pressure. This data is used to derive critical combustion metrics such as heat release rate, peak pressure, ignition delay, and combustion duration. Additionally, high-speed imaging techniques are employed to capture flame propagation and air-fuel mixing quality, providing deeper insights into combustion efficiency and emissions characteristics.

The performance of the engine is evaluated under varying operating conditions, including different RPM levels, throttle positions, and load variations. Parameters such as brake thermal efficiency (BTE), indicated mean effective pressure (IMEP), mechanical efficiency, and specific fuel consumption (SFC) are measured and analyzed to identify the most efficient engine configurations. To assess the environmental impact, emissions measurement is conducted using advanced gas analyzers and particulate matter sensors, focusing on pollutants such as carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NOx), hydrocarbons (HC), and particulate matter (PM). Emission control technologies such as exhaust gas recirculation (EGR), catalytic converters, diesel particulate filters (DPF), and selective catalytic reduction (SCR) are tested to determine their effectiveness in reducing harmful emissions.

Further analysis is conducted on hybridization and waste heat recovery strategies to improve fuel economy and overall engine efficiency. The integration of electric motors with the IC engine is explored, along with regenerative braking and stop-start systems to reduce fuel consumption. Additionally, waste heat recovery technologies such as turbo compounding and thermoelectric generators (TEG) are examined for their potential to convert excess exhaust and cooling system heat into usable energy. To enhance real-time performance optimization, machine learning techniques such as neural networks, genetic algorithms, and reinforcement learning are implemented. These AI-driven models dynamically adjust engine parameters, optimizing fuel injection, ignition timing, and throttle control for maximum efficiency and minimal emissions.

The final phase of the experimental analysis involves a comparative assessment of results obtained from different fuel types, combustion strategies, and emission control methods. The experimental findings are validated against computational simulation results to ensure accuracy and reliability. A comprehensive analysis is conducted to determine the best-performing engine configurations, providing valuable recommendations for real-world applications. The study concludes by summarizing key findings and suggesting future research directions, such as further electrification of IC engines, hydrogen-based combustion, and next-generation biofuels. Through this detailed experimental approach, the study aims to develop more efficient, environmentally friendly internal combustion engine technologies while ensuring economic feasibility and regulatory compliance.

5. CONCLUSION

The study on internal combustion (IC) engine optimization provides valuable insights into enhancing fuel efficiency, reducing emissions, and integrating alternative fuels and advanced technologies for sustainable engine performance. Through a combination of computational modeling, experimental analysis, and real-world validation, the research demonstrates the potential of various modifications, including optimized fuel injection strategies, hybridization, alternative fuels, and AI-driven engine control. The findings reveal that by adopting advanced combustion techniques, waste heat recovery systems, and emission control technologies, IC engines can achieve significant improvements in efficiency while minimizing their environmental impact.The experimental results confirm that alternative fuels such as ethanol, biodiesel, and hydrogen can be viable substitutes for conventional fuels, offering cleaner combustion and lower greenhouse gas emissions. Additionally, hybridization and machine learning-based optimization strategies have shown promise in dynamically adjusting engine parameters for enhanced performance under varying conditions. The successful integration of these technologies can contribute to the long-term sustainability of IC engines, particularly in sectors where complete electrification is not yet feasible, such as heavy-duty transportation and industrial applications.
Despite these advancements, challenges remain in achieving widespread adoption due to economic constraints, infrastructure requirements, and regulatory compliance. Future research should focus on refining hybrid powertrains, exploring hydrogen-based combustion, and further improving AI-driven engine control systems to maximize efficiency and reliability. With continued innovation and collaboration between researchers, industry stakeholders, and policymakers, IC engines can be transformed into more environmentally friendly and energy-efficient systems, playing a crucial role in the transition toward cleaner transportation and energy solutions.

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