ANALYZING VEHICLE PERFORMANCE FOR PETROL, HYBRID AND ELECTRIC CARS USING MATLAB

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Abstract: This research utilizes MATLAB to analyze the performance of various vehicle propulsion technologies, including petrol, hybrid, and electric powertrains. It focuses on torque characteristics, road resistance impact, performance metrics, braking dynamics, and driving range simulations. The study assesses critical parameters such as maximum speed, acceleration time, and electric vehicle range, while also exploring braking efficiency and stability enhancements through the Anti-Lock Braking System (ABS). By combining theoretical understanding with practical application, the research provides valuable insights for enhancing vehicle design and operation across different driving scenarios and propulsion technologies.

Keywords: Automotive sector, transformation, vehicle propulsion, petrol, hybrid, electric powertrains, MATLAB analysis, torque characteristics, road resistance, performance metrics, braking dynamic.

1. INTRODUCTION

Vehicle propulsion technologies have evolved significantly, driven by innovation and societal shifts. Initially, internal combustion engines (ICEs) replaced horse-drawn carriages, leading to unprecedented mobility. Mass production techniques in the early 20th century made cars more accessible, while mid-century advancements improved performance and efficiency [1]. Concerns about environmental impact in the latter 20th century spurred research into hybrid vehicles, combining combustion engines with electric motors [1]. The 21st century saw a shift towards electric propulsion, driven by advances in battery technology and environmental concerns. Governments and industries are investing in electric vehicles (EVs) and exploring integration with the energy grid [2]. This research uses MATLAB to delve into vehicle performance across propulsion technologies, aiming to contribute to the evolution towards more efficient and environmentally responsible transportation [2].

The dissertation sets out to explore and analyze various facets of vehicle performance across a spectrum of propulsion technologies, including petrol, hybrid, and electric vehicles [3]. The first objective involves a detailed examination of characteristic curves, focusing on how engine or motor torque interacts with road resistance. Using MATLAB simulations, this analysis aims to provide insights into the dynamic relationship between torque and speed ratios across different propulsion systems [3].

Moving on, the second objective revolves around the calculation and interpretation of performance metrics such as maximum vehicle speed, acceleration time, and gradeability [4]. Through this, the research seeks to understand how road resistance and external factors impact vehicle power requirements and overall efficiency, facilitating comparisons between different propulsion technologies in terms of energy consumption and power output [4].

A significant focus of the dissertation lies in understanding braking performance and stability, addressed in the third objective. By delving into vehicle braking dynamics and the role of Anti-Lock Braking Systems (ABS), the study aims to analyze braking efficiency, stopping distances, and the interplay between regenerative and traditional braking systems, leveraging MATLAB simulations to model vehicle stability under various conditions [4].

The fourth objective shifts attention towards electric vehicle performance and simulation, with a specific emphasis on factors influencing power performance, driving range, and battery efficiency for both Battery Electric Vehicles (BEVs) and Extended Range Electric Vehicles (E-REVs) [5]. Through driving range simulations and power characteristic matching using MATLAB, the research aims to optimize electric motor selection to meet vehicle resistance requirements effectively [5].

Another area of exploration lies in the analysis of Fuel Cell Electric Vehicles (FCEVs) in the fifth objective. By establishing mathematical models and conducting simulations, the study aims to understand the driving range under specific conditions, such as the New European Driving Cycle (NEDC) [6], and assess the feasibility of integrating fuel cells for enhanced power performance and energy efficiency.

The sixth objective focuses on parameter matching and design optimization, aiming to select motors and batteries that align with the design requirements of electric vehicles. Through battery parameter matching and analysis of trade-offs between vehicle parameters, the research seeks to achieve optimal performance while balancing considerations of range, efficiency, and design constraints [6].

Lastly, the seventh objective centers on simulation and performance prediction, leveraging dynamic characteristic graphs and MATLAB simulations to simulate vehicle dynamics and predict performance under various driving conditions. This analysis aims to provide insights into the influence of parameters such as aerodynamics, weight, and tire characteristics on overall vehicle performance.

Overall, through these objectives, the dissertation aims to offer a comprehensive analysis of vehicle performance across different propulsion technologies, using advanced simulation techniques and modeling tools to deepen our understanding of vehicle behavior and drive advancements in future vehicle design and operation.

2. LITERATURE SURVEY

H. S. Pavan et al. (2022): With the global rise in demand for electric vehicles due to emission regulations, concerns about battery lifespan, mileage, and charging time persist. To address these issues, the study suggests a hybrid energy storage system using batteries and fuel cells, controlled by a robust Energy Management System (EMS). The EMS, operated by a classical PI controller, enhances hydrogen consumption efficiency and cruising range [7].

J. Dong and J. Bauman (2022): Investigating sustainable passenger transport options, the study explores Battery Electric Vehicles (BEVs) and Fuel Cell Hybrid Vehicles (FCHVs). Introducing a fuel cell range extender vehicle (FCREV) concept, they optimize driving range by utilizing the fuel cell to charge the battery during driving and parking. Analytical optimization results in a cost-effective FCREV with significant range enhancement compared to BEVs [8].

G. Huang et al. (2022): Aiming to improve electric vehicle energy efficiency and range, this study proposes a novel energy management strategy based on deep reinforcement learning (DRL). Using gated recurrent units (GRU) and double deep Q-network (double DQN) algorithms, the approach optimizes energy efficiency while considering battery thermal effects. Simulation results demonstrate a significant energy reduction during aggressive driving compared to existing control methods [9].

P. Zheng and J. Bauman (2022): Addressing challenges faced by electric vehicles such as limited range and slow refueling, the study explores integrating solar and fuel cell technologies to extend range. They propose a practical multi-port converter to facilitate this integration, with simulation results validating its operation and potential benefits for vehicle performance [10].

A. Ferrara and C. Hametner (2022): Focusing on eco-driving for fuel cell electric trucks, this study emphasizes the importance of optimal speed planning in enhancing vehicle efficiency and range. Using dynamic programming and Pontryagin's minimum principle, they develop an optimal speed plan that increases vehicle range by 8% compared to constant speed plans, offering potential extensions up to 50% in areas with limited hydrogen infrastructure [11].

B. Balasingam et al. (2022): Highlighting the significance of Battery Management Systems (BMS) for safety and performance in electric vehicles, the study emphasizes their role in controlling charging and safeguarding batteries from extreme conditions. BMS ensures efficiency and longevity in various applications, including electric vehicles, contributing to overall vehicle performance and safety [12].

3. PROPOSED WORK

The proposed work outlines a comprehensive process for simulating and analyzing vehicle performance across different propulsion technologies using MATLAB. It begins by initializing simulation parameters and vehicle characteristics, then proceeds to develop dynamic simulation models for each propulsion technology, incorporating equations for power delivery, torque-speed relationships, and efficiency.

Next, the simulation process involves simulating vehicle performance under various driving conditions, calculating acceleration, maximum speed, and driving range, and analyzing power requirements, efficiency, and energy consumption. Braking efficiency and stability are evaluated, and motor, battery, or fuel cell parameters are matched for optimization.

The impact of parameters on power performance is simulated, and results are analyzed and interpreted in relation to research questions and objectives. Conclusions are drawn based on the analysis, recommendations are provided for vehicle design and policy formulation, and areas for future research are identified.

Overall, the process aims to provide a thorough understanding of vehicle performance characteristics and interactions across different propulsion technologies, with implications for the automotive industry and sustainability.Related Work

Plug-in Hybrid Electric Vehicles (PHEVs) represent an evolution of conventional hybrid technology, offering increased electric driving range and the ability to recharge their larger batteries from an external power source [8]. Let's delve into the details of PHEVs, including their distinction from conventional hybrids, larger batteries and charging capabilities, as well as their advantages and limitations.

4. RESULT ANALYSIS

Parallel Hybrid Electric Vehicle

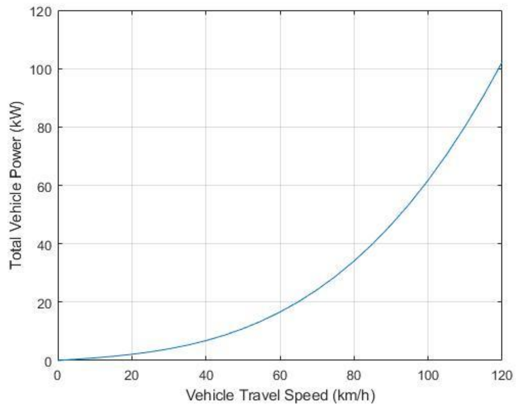

Fig 1. NEDC Cycles

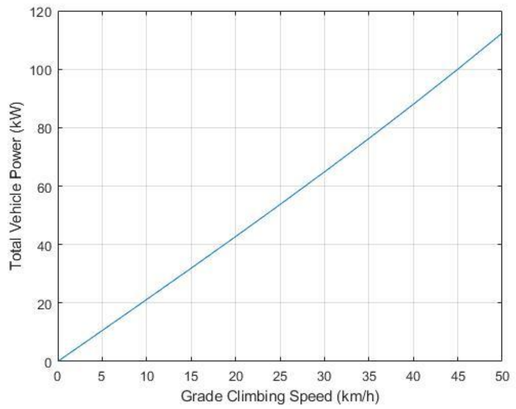

Fig 2. Grade Climbing Speed

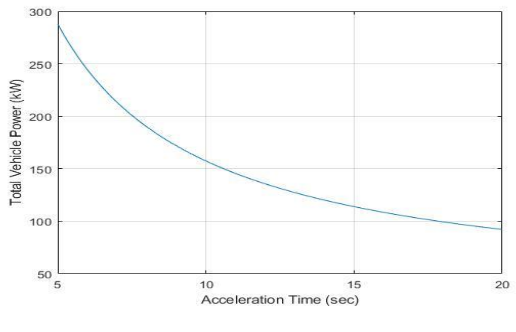

Fig 3. Acceleration Time

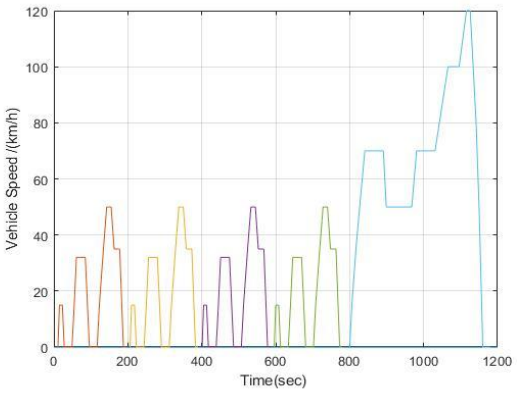

Fig 4. New European Driving Cycle (NEDC)

The code simulates and visualizes the vehicle speed profile during the urban and suburban driving portions of the New European Driving Cycle (NEDC). It sets the range for the x-axis (time in seconds) and y-axis (vehicle speed in km/h) for the graph to be plotted later.

For the urban driving portion, it simulates acceleration, constant speed, and deceleration phases for the first loop, plotting the vehicle speed profile over time using the plot() function. This speed profile is then extended to subsequent urban cycle loops to create a continuous speed profile.

Similarly, for the suburban driving portion, it simulates acceleration, constant speed, and deceleration phases with appropriate speed values. The xlabel() and ylabel() functions label the axes, and grid on command turns on grid lines in the graph.

5. CONCLUSION

In conclusion, this research comprehensively analyzed various vehicle propulsion technologies, including petrol, hybrid, and electric powertrains, using MATLAB. It successfully achieved its objectives of investigating torque characteristics, assessing road resistance impact, analyzing performance metrics, examining braking dynamics, and simulating driving range scenarios. The study utilized characteristic curves and dynamic simulations to deepen understanding of power performance and critical parameters like maximum speed and acceleration time. It also explored braking performance, optimized power systems for electric and fuel cell vehicles, and provided insights into driving range management. Overall, the research offers valuable insights for enhancing vehicle design and operation in the automotive sector.

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