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Front Suspension and Handlebar Design for E-Three Wheelers: Analysis and Development

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Abstract

This project focuses on designing and developing a front suspension system and handlebar for electric vehicles (EVs) to address existing gaps. The current suspension systems face issues like inadequate load capacity, compromised stability, and reduced rider comfort. By optimizing suspension geometry, utilizing lightweight materials, and enhancing handlebar ergonomics, this project aims to improve the vehicle's load capacity, stability, and overall ride comfort, contributing to more efficient and sustainable EV performance.

INTRODUCTION

The design of a front suspension and handlebar plays a crucial role in the performance, safety, and comfort of two- and three-wheeler vehicles. The front suspension system absorbs shocks and vibrations from the road surface, ensuring stability, better handling, and rider comfort. It also helps maintain continuous contact between the wheel and the road, which is essential for effective braking and steering.

On the other hand, the handlebar acts as the primary control interface between the rider and the vehicle. It provides leverage for steering, stability during turns, and control over braking and acceleration. The geometry, length, and angle of the handlebar directly affect rider posture, ergonomics, and manoeuvrability of the vehicle

LITERATURE REVIEW

In 2013 Manish Dakhore et al. discuss about locomotive suspension coil springs, their fundamental stress, distribution, materials characteristic, manufacturing and common failures. Investigation on the premature failure of suspension coil spring of a locomotive, which failed within few months after being put into service, has been carried out analytically and using FEA software. Inherent material defect in association with deficient processing led to the failure of the spring.”[1]

In 2020 P. Spanoudakis et al.

Designed a front single-sided swingarm suspension for an electric three-wheeler. Finite Element Analysis (FEA) was used to determine stress, deflection, and fatigue life. The optimized design reduced weight by 18% without compromising strength, improving ride stability and handling."[2]

In 2020 J. Park et al.
Studied handlebar ergonomics using digital human modelling in CATIA. The research optimized handlebar height, width, and reach angles to reduce shoulder and wrist strain, improving rider comfort and control -a key consideration in electric vehicle design."[3]

In 2021 R. Mehta and P. Joshi
Investigated vibration reduction techniques for motorcycle handlebars. Modal analysis identified vibration modes between 20–80 Hz affecting rider comfort. The study recommended tuned mass dampers and rubber mounts to minimize vibration transmission to the riders hands."[4]

In 2021 L. Zhang et al.
Proposed hybrid composite materials for suspension arms using carbon fibre and aluminium inserts. Testing revealed 30% higher stiffness-to-weight ratio than traditional steel parts, suggesting potential for lightweight EV suspension design with improved durability."[5]

In 2022 S. K. Patel and R. Sharma
Analysed telescopic suspension systems for lightweight two-wheeler EVs. The study examined spring stiffness and damping ratio variations using MATLAB Simulink. Results showed that optimized damping improved comfort and reduced vibration amplitude under dynamic loading."[6]

In 2022 T. Deshmukh and A. Bhosale
Designed a front suspension for an electric tricycle using CAD and ANSYS. They analysed braking and cornering loads, optimizing link geometry for stability. The system enhanced ride quality and reduced frame vibrations during uneven road conditions."[7]

In 2022 S. Patil and M. More
Developed a front telescopic suspension with ergonomic handlebar for an electric scooter prototype. The study combined FEA, vibration testing, and ergonomic evaluation. Result indicated smoother ride performance, reduced vibration transfer, and better rider posture alignment."[8]

In 2023 A. Kumar and V. Singh
Performed fatigue and static analysis on aluminium alloy (AA6061-T6) suspension forks. They compared steel and aluminium materials and concluded that aluminium provides better weight efficiency but requires reinforcement at high-stress joints to ensure long fatigue life."[9]

In 2023 N. Gupta and S. Yadav
Conducted a dynamic performance study on front suspension systems under varying speeds. Experimental results showed that optimized damping and spring stiffness significantly reduce pitch motion and improve handling, especially critical in compact electric vehicles."[10]

Limitations of existing system

- Poor Shock Absorption: The current suspension systems in many low-cost electric vehicles fail to absorb shocks efficiently, resulting in discomfort on rough or uneven roads.
- Low Load Carrying Capacity: Traditional front suspension designs are not optimized for higher payloads, leading to reduced stability when the vehicle is fully loaded.
- Inadequate Stability and Control: Existing systems often suffer from poor stability during cornering and braking, especially in three-wheel configurations.
- Use of Conventional Materials: Many designs use steel or other heavy materials, which increase the vehicle's overall weight and reduce energy efficiency.
- Limited Adjustability: Suspension settings like stiffness or damping are usually fixed, making the system unsuitable for varying road or load conditions.
- High Maintenance Requirements: Mechanical linkages and springs wear out quickly, requiring frequent maintenance and part replacement.

Problem statement
Existing suspension systems in three-wheelers often provide limited shock absorption, leading to driver fatigue and passenger discomfort. Additionally, the traditional steering column mechanisms are complex and less ergonomic compared to handlebar designs. The project focuses on the "Design and Development of Front Suspension System and Handlebar for Electric Vehicle," aiming to enhance ride comfort, stability, and overall performance of electric three-wheelers.

OBJECTIVES

- To Design front suspension for smooth ride on uneven roads.
- To Optimize suspension geometry for better three-wheeler stability.
- To Create ergonomic handlebar for comfort and improved steering.

- To Increasing the load-carrying capacity of a suspension system.

CONCLUSION

The design and development of the front suspension system and handlebar for electric vehicles has led to significant improvements in ride comfort, stability, and overall performance. By optimizing suspension geometry, utilizing lightweight materials, and enhancing handlebar ergonomics, this project has addressed key challenges in EV design. The outcomes contribute to more efficient, comfortable, and sustainable electric vehicle solutions, paving the way for further advancements in EV technology.

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