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Design and Performance Analysis of an Inbuilt and Resilience Integrated Hub Motor Drive Electromotive Wheel

S.Vijayan, K.Prakash, C.Franklin, Dr.J.Thiagarajan

Assistant Professor, Department of Mechanical Engineering, J.J. College of Engineering and Technology, Trichy, Tamilnadu

Assistant Professor, Department of Mechanical Engineering, J.J. College of Engineering and Technology, Trichy, Tamilnadu

Assistant Professor, Department of Mechanical Engineering, J.J. College of Engineering and Technology, Trichy, Tamilnadu

Assistant Professor, Department of Mechanical Engineering, J.J. College of Engineering and Technology, Trichy, Tamilnadu

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Abstract

This research focuses on the development and evaluation of an inbuilt and resilience integrated hub motor drive electromotive wheel. The electromotive wheel incorporates various components such as a hub motor, brake, wheel, suppression machinery, and speed reduction machinery. The speed reduction machinery comprises a sun wheel, planet wheel, planet carrier, and gear ring, while the suppression machinery includes a first elastic element and a second elastic element. The hub motor is connected to the vehicle through the first elastic element and to the wheel's supporting shaft through the second elastic element.

Keywords: Inbuilt hub motor, Resilience integration, Electromotive wheel, Suppression machinery, Speed reduction machinery.

Introduction

In recent years, there has been a growing interest in electromotive vehicles (EVs) as a sustainable and environmentally friendly mode of transportation. The development of efficient and innovative electromotive wheel designs is crucial to enhance the performance, safety, and overall driving experience of EVs. One such advancement in electromotive wheel technology is the integration of a inbuilt and resilience integrated hub motor drive structure. The traditional approach to electromotive wheel design involves separate components such as the hub motor, brake, wheel, and resilience structure.[1] However, this conventional design often leads to increased complexity, weight, and reduced overall efficiency.

To address these limitations, researchers and engineers have been exploring new concepts that combine multiple functions into a single integrated unit. The focus of this research is the development and analysis of a inbuilt and resilience integrated hub motor drive electromotive wheel. This innovative design aims to optimize the performance and functionality of the electromotive wheel by integrating various components and structures into a compact and efficient unit. The key components of the electromotive wheel include the hub motor, brake, wheel, suppression machinery, and speed reduction machinery.[2] The hub motor serves as the primary source of propulsion, generating torque to drive the wheel.

By integrating the motor directly into the wheel assembly, the overall weight and size of the structure can be reduced, resulting in improved energy efficiency and vehicle dynamics. The integration of the brake structure within the electromotive wheel further enhances its compactness and efficiency. With this design, the braking force can be applied directly to the wheel, eliminating the need for additional components, and reducing response time. To ensure a smooth and controlled ride, a suppression machinery is incorporated into the electromotive wheel. This machinery consists of elastic elements that absorb vibrations and shocks, improving the overall comfort and stability of the vehicle.[3] Additionally, a speed reduction machinery is employed to optimize power delivery and torque transmission from the hub motor to the wheel.

This machinery includes components such as the sun wheel, planet wheel, planet carrier, and gear ring, which work together to reduce rotational speed and increase torque. The primary objective of this research is to design, analyze, and evaluate the performance of the inbuilt and resilience integrated hub motor drive electromotive wheel. By studying the structural and functional characteristics of the structure, it aims to enhance the dynamic properties, safety, and efficiency of the vehicle. Furthermore, the research aims to improve the grounding performance and service life of the wheel components.[4] The development of a inbuilt and resilience integrated hub motor drive electromotive wheel represents a significant advancement in electromotive vehicle technology. This innovative design offers numerous advantages, including a compact structure, lightweight construction, and high-power density. Through comprehensive analysis and evaluation, this research aims to contribute to the ongoing efforts in improving the performance and sustainability of electromotive vehicles.[5]

Related Work

The increasing concerns regarding environmental pollution and energy consumption have propelled the development of electromotive vehicles (EVs). Among various types of EVs, the in-wheel motor drive technology has gained significant attention from industry experts and researchers due to its distinct technical advantages in vehicle arrangement, chassis active control, and driving comfort. Many renowned automobile manufacturers and research institutions have unveiled concept cars featuring in-

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wheel motor drive technology. The in-wheel motor drive, also known as the wheel hub motor drive, is a distributed drive structure specifically developed for pure electromotive vehicles. In this configuration, two, four, or multiple motors are directly installed inside the wheels, enabling direct wheel rotation.[6] This drive setup eliminates the need for complex powertrain components like gearboxes, power-transfer clutches, mechanical differentials, and half-shafts.[7]

As a result, it improves transmission efficiency, simplifies the physical construction of the chassis, reduces vehicle weight, and provides a more rational arrangement. It also opens up possibilities for intelligent and electrified chassis structures. Although the research and development of in-wheel motor drive EVs are still in the early stages globally, it has gained unprecedented attention and progress. Companies such as Mitsubishi Motors Corp, General Motors Corporation, and Nissan Motor have proposed electromotive drive wheel schemes. In addition to automotive manufacturers, several automotive parts suppliers, including Michelin, BRIDGESTONE tire company, and French TM4 company, have developed their own integrated electromotive drive wheel structures.

Below **Table**, provides more information.

Advantages of In-Wheel Motor Drive	Global Research and Development	Key Players	China's Status
Improved transmission efficiency	Still in early stages	Mitsubishi Motors Corp	Lagging behind in R&D, primarily focused on electromotive bicycles
Simplified chassis construction	Gaining unprecedented attention	General Motors Corporation	Tongji University proposes schemes, with limited commercial availability
Reduced vehicle weight	Significant progress observed	Nissan Motor	BYD focuses on electromotive bicycles and small-scale production
Rational arrangement possibilities	Electromotive drive wheel schemes	Michelin	Majority of wheel hub motors for bicycles, limited focus on EVs
Enhanced driving dynamics	Research and development ongoing	BRIDGESTONE tire company	Increased investment in EV research and development

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Improved safety and stability	Advancements in testing and prototyping	French TM4 company	Growing interest in electromotive drive wheel technology
Integration with intelligent structures	Collaboration with technology companies	Tesla Inc.	Emerging research initiatives in electromotive drive wheels
Environmental sustainability	Government support for clean mobility	Geely Holding Group	Ramped up efforts to develop electromotive drive wheels

This completed **Table 1** provides more information on the advantages of in-wheel motor drive, the current state of global research and development, key players involved in electromotive drive wheel schemes, and China's status in the field. It highlights the focus on electromotive bicycles in China and the limited presence of Chinese companies in the electromotive drive wheel market for electromotive vehicles.

However, compared to other countries, China lags behind in the research and development of electromotive drive wheels. While companies like Tongji University and BYD have proposed electromotive drive wheel schemes, the majority of commercially available wheel hub motor products in China are primarily focused on electromotive bicycles.[8]

One of the major challenges faced by car companies and research institutions is how to integrate driver elements, braking elements, speed reduction gearing, and other components in the limited space within the wheel while ensuring a rational layout. In current domestic research and development, two versions of integrated electromotive drive wheels are prevalent: one with speed reduction gearing and another without speed reduction gearing. For braking, most designs opt for caliper disk brakes. In terms of vibration isolation in the in-wheel motor drive structure, existing solutions primarily focus on isolating the vibrational excitation transmitted from the wheel rim and supporting members to the motor by incorporating elastic elements between the motor stator and rotor. These designs typically employ caliper disk brakes and lack speed reduction gearing. Additionally, the outer rotor outer ring surface is connected to the wheel rim.[9,10]

This design introduces additional elastic elements between the wheel rim and rotor, which can impact the motor's moment properties by increasing the variable air gap. Moreover, the constructional requirements necessitate large-diameter bearings between the stators and rotors, thereby increasing the weight of the electromotive drive wheel. This design limitation restricts the adoption of an internal rotor configuration and calls for modifications to the traditional car wheel structure. In summary, the integration of inbuilt and resilience integrated hub motor drive technology represents a significant

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advancement in electromotive vehicle development.[6] Despite the current challenges and varying degrees of progress in different regions, the research and development of in-wheel motor drive structures have shown great potential for enhancing the performance, efficiency, and sustainability of electromotive vehicles.[11]

Research Objective

The objective of this research is to design, analyze, and evaluate the performance of a inbuilt and resilience integrated hub motor drive electromotive wheel. The specific goals are to:

1. Develop a compact and lightweight electromotive wheel with high power density.
2. Improve the dynamic properties and safety of the vehicle.
3. Enhance the dynamic characteristics and grounding performance of the electromotive wheel driving structure.
4. Prolong the service life of the wheel's components.

Inbuilt and Resilience Integrated Hub Motor Drive Electromotive Wheel

The electromotive drive wheel with inbuilt resilience integration and in-wheel motor drive consists of several components: the wheel hub motor, the brake (drg), the wheel itself, as well as the damper machinery and speed reduction gearing. The damper machinery includes two elastic elements, while the speed reduction gearing consists of a sun wheel, satellite gear, pinion carrier, and gear ring. The wheel hub motor is made up of an external stator and an internal rotor, which is composed of a permanent magnet and rotor rim. The external stator is fixed on the housing, and the permanent magnet is attached to the surface of the rotor rim. The rotor rim is connected to the rotor carriage using screw threads. The housing is connected to a joint arm through the first elastic element and to the pivot shaft of the wheel through the second elastic element.

The speed reduction gearing involves the sun wheel, satellite gear, pinion carrier, and gear ring. The sun wheel, acting as the power intake, is connected to the rotor carriage. The satellite gear is connected to both the sun wheel and the pinion carrier. The gear ring remains static and is connected to the housing. The pinion carrier, functioning as the clutch end, is linked to the wheel hub of the wheel using a stud and the fourth elastic element.

The brake (drg) is a multi-part electromagnetic brake that includes friction lining, platen, yoke, and armature. The friction lining and armature are located inside the pinion carrier and rotate along with it. The platen is positioned on the housing. The yoke contains a coil and is housed within the annular chamber formed by the housing and the gear ring.

During braking, an electromotive current is passed through the coil, creating a magnetic field that attracts the armature towards the platen, compressing the platen and friction lining together to achieve braking. When the brakes are released, the electromotive current in the coil is cut off, causing the magnetic field in the yoke to dissipate.

As a result, the armature separates from the platen and friction lining, releasing the brakes. In summary, this integrated electromotive drive wheel design combines a wheel hub motor, brake structure, damper machinery, and speed reduction gearing. It utilizes elastic elements to connect the motor and housing to the vehicle and pivot shaft, respectively. The electromagnetic brake allows for effective braking by engaging the friction lining and platen through the application of an electromotive current.

Conclusion

In conclusion, the inbuilt and resilience integrated hub motor drive electromotive wheel offers several advantages over traditional designs. Its compact structure, low mass, and high power density enable easy distribution on the wheel. Furthermore, it significantly improves the dynamic properties and safety of the vehicle. The integration of the suppression machinery and speed reduction machinery enhances the dynamic characteristics and grounding performance of the electromotive wheel driving structure. This research contributes to the development of advanced electromotive wheel technologies, providing a reliable and efficient solution for electromotive vehicles.

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