

Research on the Lightweight Path of Automotive Drum Brakes

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Abstract: In the evolution of the automotive industry, the impetus from energy conservation and emission reduction policies has rendered automotive lightweighting an inescapable tendency. This article centers on dissecting the historical progression and forthcoming trends of structural lightweighting, lucidly expounding the essential significance of lightweighting across a multitude of sectors. Concurrently, it delves profoundly into the lightweight design methodologies for automotive drum brakes and also anticipates the future prospects of automotive drum brake lightweighting, thereby furnishing the automotive industry with a theoretical underpinning and practical counsel to fulfill the lightweighting objectives.

Keywords: Automotive Drum Brakes; Lightweighting; Future Outlook

1. INTRODUCTION

Amid the swift expansion of the automotive industry, the attainment of energy conservation, emission reduction, and performance enhancement has emerged as the central focus. Automotive lightweighting has thereby evolved into an inexorable trend. The automotive drum brake constitutes a vital component within the automotive braking framework. Its lightweighting holds substantial value in curtailing the overall vehicle weight, augmenting fuel economy, and bolstering braking efficacy^[1].

2. THE EVOLUTION AND FUTURE TRENDS OF STRUCTURAL LIGHTWEIGHTING

2.1 Concept and Significance of Lightweighting

(1) Concept Explanation

Lightweighting refers to the reduction of material usage through design optimization and the employment of novel materials while guaranteeing product performance. The diminished material quantity can not only lower costs but also reduce resource consumption. Retaining strength and rigidity ensures the safety and reliability of products during utilization. Enhanced energy efficiency and performance enable products to satisfy the demands of contemporary technological progress.

(2) Explanation of Significance

Lightweighting is capable of efficiently diminishing energy consumption. In the context of automotive transportation, it leads to a reduction in energy usage, an enhancement of transportation efficiency, and a shortening of transportation time owing to the decreased load. Simultaneously, it contributes to environmental protection and sustainable development by lessening resource consumption and waste generation.

2.2 Development History

(1) Early Exploration Stage

Structural lightweighting initially found its application in the aerospace domain, aiming at cost reduction and performance enhancement. With the ceaseless advancement of composite

materials and novel alloys, a foundation was laid for the actualization of lightweight design. Additionally, the design approaches based on shape optimization and topology optimization also propelled the progress of this development.

(2) Gradual Promotion Stage

In the automotive sector, the utilization of intelligent design and state-of-the-art materials has spurred the elevation of the automotive lightweighting level, consequently augmenting fuel economy and safety performance. Within the construction industry, by dint of new materials and technologies, structural stability has been ameliorated and construction efficiency has also been boosted. Additionally, diverse industries are perpetually probing and evolving high-performance materials, like composite materials and renewable materials, with the aim of attaining the objectives of environmental protection and high efficiency.

2.3 Analysis of the Current Situation

(1) Current Technologies and Methods

Typical lightweight materials encompass aluminum and carbon fiber, among others. Owing to their remarkable strength-to-weight ratios, they are extensively employed in areas such as aerospace and automotive industries. Contemporary design methodologies like topology optimization are capable of enhancing structural performance and minimizing material wastage. Computer simulation technology is utilized to perform virtual testing and analysis, thus augmenting the dependability of the design and optimizing cost-effectiveness^[2].

(2) Market Demand and Challenges

The requirements for lightweighting technologies differ across diverse industries, making it essential to formulate customized and specialized solutions. Despite the fact that the continuous technological advancements can result in cost reductions, the initial investment is frequently substantial. Therefore, the payback period demands evaluation. In addition, matters concerning the recycling and disposal of products also merit attention to fulfill the objective of sustainable development.

2.4 Future Development Trends

(1) New Material Development

Renewable and eco-friendly materials will witness more extensive utilization to mitigate environmental pollution. Ultra-lightweight and high-strength materials continue to surface, presenting novel prospects for sectors such as aerospace and automotive. Nanotechnology holds vast application potential. It can enhance the performance of materials and be applied in a multitude of fields.

(2) Intelligent Manufacturing and Lightweighting

The combination of automated production lines and lightweight design is capable of enhancing production efficiency and decreasing costs. Artificial intelligence can refine the design and boost product quality and competitiveness. The analysis and feedback of real-time data contribute to the optimization of the production process.

(3) Summary and Prospect of Structural Lightweighting

Across diverse industries, data-driven decision-making, cross-border integration, and the elevation of employees' skills will all assume highly significant roles. Structural lightweighting exerts a notable promotional influence on environmental protection, resource recycling, and technological innovation. Concurrently, emerging technologies have also introduced entirely novel opportunities and possess more extensive application vistas in sectors such as healthcare, education, and smart cities..

3. RESEARCH ON THE LIGHTWEIGHTING PATH OF AUTOMOTIVE DRUM BRAKES

Conventional automotive drum brakes predominantly employ cast iron and composite materials. However, they suffer from issues like relatively high weight and subpar friction performance. Given the progressively prominent trend of automotive lightweighting, probing into novel materials and advanced technologies to surmount the lightweighting hurdles and fulfill the requisites of safety, durability, and economy has emerged as the central undertaking within the industry.

3.1 Lightweight Design Methods

(1) Material Selection

Novel lightweight materials possess the merits of low density and high strength. For instance, the utilization of magnesium alloys and aluminum alloys in automotive components has manifested a highly conspicuous weight reduction effect. Composite materials attain the objective of lightweighting while guaranteeing strength. It is of utmost importance to carry out a comprehensive contemplation and assessment of material strength and other characteristics (such as heat resistance, corrosion resistance, etc.) during the material selection process.

(2) Weight Reduction Design Principles and Analysis Methods

By way of proper material selection and structural optimization, the weight of components can be lessened, thereby enhancing the overall performance and fuel efficiency of automobiles. Employ finite element analysis to perform structural stress inspection in order to confirm the safety of the design and the lightweighting outcome. Contrast the traditional structures with the innovative ones and select

substitute materials that are lighter and possess higher strength.

3.2 ANSYS Analysis Application

(1) Result Evaluation

Leverage ANSYS to execute numerical simulations regarding stress and displacement for automotive drum brakes, thereby pinpointing the structural weak points and potential failure areas. Illustrate the optimization process and outcomes via practical examples, and assess the efficacy of the lightweight design by means of quantitative metrics such as the weight reduction percentage and the performance enhancement scope.

(2) Experimental verification

Carry out practical tests on samples using precision instruments and gather data. Compare the outcomes from simulations with the measured data to appraise the precision and dependability of the model. Examine the influence of the test environment and conditions on the results to guarantee the repeatability and validity of the tests. Furnish optimization proposals according to the feedback, and ascertain the iteration path of the design and the anticipated performance of the final product.

4. Future Prospects of the Lightweighting of Automotive Drum Brakes

4.1 Prospects for Research on New Materials

The advancement of materials science will fuel the evolution of novel composite and functional materials, augment product performance, and reinforce environmental protection. In tandem with the progression of science and technology and the elevation of industries, the market appetite for new materials persists in swelling. Governments across the globe have successively rolled out policies to bolster the research and development of new materials with the aim of elevating the caliber of independent innovation.

4.2 Digital and Intelligent Design

The employment of digital tools in material selection and structural simulation is capable of enhancing the efficiency and precision of design. The intelligent algorithms generated by integrating machine learning and big data analysis can streamline the design process and reach the objective of intelligent design. Constructing a closed-loop feedback system allows for real-time modifications to the design plan, thus enhancing the performance of products.

4.3 Automated manufacturing process

Employing robotics and automated apparatus to construct intelligent production lines is able to enhance production efficiency and curtail labor costs. With the assistance of Internet of Things technology, the surveillance and optimization of the production process can be accomplished. By incorporating the concept of lean production, expenses can be slashed, quality can be enhanced, and the production cycle can be abbreviated.

4.4 Market demand and competitive landscape.

Presently, contemporary consumers have a stronger preference for environmentally friendly and sustainable products, and their demands regarding automotive performance and safety are on the rise. Simultaneously, the

need for personalized customization is continuously expanding. The competition within the industry has become more and more intense, with various competitors constantly innovating technologies and adjusting marketing strategies. The trends of electrification and intelligence in the automotive industry are prominent, and policies concerning sustainable development are impelling the industry to progress in an environmentally friendly direction.

5. CONCLUSION

The lightweighting of automotive drum brakes represents a crucial trend in the automotive industry's evolution. Via research on structural lightweighting and investigations into the means of reducing the weight of drum brakes, we have grasped the essential importance of material selection, the enhancement of design methodologies, the application of analytical techniques, and experimental verification. In the days to come, the progress of novel materials, digital and intelligent design, automated manufacturing, and the management of market demands will jointly facilitate more sustainable advancements in the lightweighting of automotive drum brakes, attain the objective of sustainable development within the automotive industry, and augment the overall performance and market competitiveness of automobiles.

During the exploration and implementation phases of automotive drum brake lightweighting, all industry stakeholders must closely track technological trends, actively confront challenges, and continuously innovate to adapt to shifts in market demands and contribute to the green and efficient advancement of the automotive sector.

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7. REFERENCES

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