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Elevators in the Context of Green Manufacturing

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Abstract: With the continuous development and wide application of modern technology, more enterprises and institutions in our country have begun to strengthen the research and manufacturing of intelligent elevators, aiming to build a new mode of modern manufacturing with the concept of green development as the core. Therefore, this paper takes green manufacturing as the background, analyzes the design significance of intelligent elevator lightweight, expounds its design ideas, and in the end introduces its specific design practice path.

Keywords: Green manufacturing; Intelligent elevator; Lightweight

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1. Introduction

Intelligent elevator lightweight refers to reducing the elevator's volume, weight, cost, and other factors while maintaining its essential functions. This is achieved by using new materials, optimizing structural design, and enhancing technology, ultimately improving the elevator's efficiency and convenience. It can be seen that strengthening the lightweight design of intelligent elevators is one of the important means to promote the realization of green manufacturing goals in China.

2. The significance of lightweight design of intelligent elevator under the background of green manufacturing

In the context of green manufacturing, the lightweight design of intelligent elevator can first effectively reduce the overall weight of the elevator. The structure of the elevator system is relatively complex and its optimization design usually requires comprehensive consideration of a variety of factors, which is difficult. The advanced structural optimization design scheme and the application of new materials can be organically combined to reduce the weight of the elevator while ensuring the performance and safety of the elevator [1]. Secondly, the lightweight design of intelligent elevator can effectively reduce the energy consumption of elevator operation and reduce the cost of manufacturing and maintenance.

Moreover, while the elevator is lightweight, it can also take into account the comfort, safety, and functionality of the elevator, which is the concrete embodiment of achieving the goal of green manufacturing. Finally, the intelligent elevator lightweight design, through the integration of intelligent simulation technology, enables precise simulation and accurate prediction of elevator structure and material usage. This not only enhances the efficiency and accuracy of intelligent elevator green design but also contributes to the development of a more refined elevator lightweight design and manufacturing system, ultimately promoting technological progress within the industry [2].

3. The light weight design idea of intelligent elevator under the background of green manufacturing

3.1. Analyze the market demand and technical background of elevator lightweight, and determine the direction of lightweight research

With the continuous acceleration of urbanization and the increasing number of densely populated areas, the use of elevators is increasing [3]. In this situation, the advantages of lightweight elevators are gradually highlighted. Compared with ordinary elevators, lightweight elevators have lower energy consumption, higher energy efficiency, and lower maintenance costs, which can better meet the development needs of the social market under the background of green manufacturing. Moreover, with the continuous development of material science, structural design, manufacturing process, and other fields, people's research and application level of lightweight materials has been significantly improved, which provides more technical support for elevator lightweight [4]. For example, carbon fiber composite materials have the characteristics of high strength, high stiffness and light weight, and have been widely used in elevator lightweight design [5]. The development and application of new manufacturing technologies such as 3D printing have also, to a certain extent, provided some new ideas and methods for the design and manufacture of lightweight elevator parts [6]. In addition, coupled with the policies and systems related to energy conservation and environmental protection, green building, and sustainable development issued by the national government, it also provides support and guarantee for the development of lightweight elevator [7]. It can be seen that the current market demand for elevator lightweight is relatively large, and the technical support is relatively rich, which lays a solid foundation for us to determine the direction of elevator lightweight research.

3.2. Learn from successful cases and advanced technologies to study the status quo and development trend of elevator lightweight at home and abroad

According to the published information, the Ultra Rope developed by KONE Company is an ultra-light, ultra-wear-resistant and ultra-efficient carbon fiber traction rope with extremely high strength and durability, which can significantly reduce the accompanying weight and energy consumption of the elevator. It also has a long service life, equivalent to twice that of ordinary steel wire ropes. The application of Ultra Rope technology not only greatly improves the operating efficiency of elevators, but also significantly reduces the carbon emissions throughout the entire life cycle [8]. The technology is also highly resistant to wind swings, strong wear resistance, and its application can reduce the frequency of elevator stops in extreme weather, helping to significantly improve elevator reliability and safety.

Many domestic elevator enterprises have also begun to focus on the research and application of elevator lightweight technology. By introducing advanced materials and design concepts, some enterprises have successfully developed a series of lightweight elevator products, which gives them a certain advantage in the fierce market competition. Taking Hangzhou Theo Elevator as an example, the company has realized the lightweight

design of elevator components by using high-strength composite materials and advanced structural design which has been well received in the market [9].

These successful cases prove that elevator lightweight technology has great application potential in improving elevator performance and saving energy. Therefore, in the context of green manufacturing, the optimal design of intelligent elevator lightweight can be realized by referring to and drawing on these successful cases and advanced technologies.

From the current point of view, the research on elevator lightweight at home and abroad is diversified, including not only the research and application of materials, such as carbon fiber, glass fiber reinforced plastic, and other lightweight high-strength materials, but also the extensive exploration of structural design, control system and other aspects [10]. In future development trends, the elevator lightweight technology will be affected by artificial intelligence technology, Internet of Things technology, etc., begin to transform and upgrade in the direction of intelligence and digitalization. For example, intelligent optimization of elevator load can be achieved through artificial intelligence control systems to further reduce car weight and energy consumption. Through the use of big data analysis and monitoring systems, to achieve real-time monitoring and prediction of elevator operation data, improve elevator operation efficiency and reliability.

All in all, with the continuous improvement of people's requirements for elevator safety and comfort, elevator lightweight design should not only reduce static load but pay more attention to improving operating efficiency and energy saving and emission reduction [11]. Therefore, elevator enterprises should further increase the research investment in lightweight technology, and strive to make new breakthroughs in materials, design, system integration, and other aspects.

3.3. Optimize the design of elevator structure and determine the lightweight program of the elevator

Elevator structure optimization design is an important way to achieve elevator lightweight. By optimizing the design of elevator structure, unnecessary weight, and material use can be greatly reduced, which is conducive to effectively reducing the weight of the whole machine. For example, by using a lighter design structure and more ingenious parts layout, the weight of the elevator body can be reduced and the carrying efficiency of the elevator can be improved. The optimal design of the elevator structure can be considered from the following aspects:

First, the use of new materials is crucial for achieving elevator lightweighting. In optimizing the elevator structure, selecting high-strength, high-toughness materials such as carbon fiber composites and magnesium alloys, instead of traditional materials, can significantly reduce the weight of the elevator structure while ensuring its safety and reliability [12]. Second, the application of intelligent control technology, which can promote the realization of the elevator lightweight goal. In the optimization design of elevator structure, through the introduction of intelligent control technology, the intelligent control and dynamic management of elevator operation can be achieved, which is conducive to reducing the energy consumption and weight of the elevator. For example, by utilizing frequency conversion drive technology, the efficiency of elevator operation can be significantly enhanced, while also reducing the wear and energy consumption of related mechanical components during operation.

The third is to cooperate with enterprises to jointly test the applied materials, to further ensure the safety and reliability of the lightweight operation of the elevator by conducting a large number of material properties and structural strength experiments. For some difficult and costly experiments, simulation technology can be used to

verify the feasibility and effect of the elevator structure optimization design scheme, and with the help of finite element analysis and other numerical simulation methods, simulate the force of the elevator in different working conditions and evaluate the impact of lightweight design on the performance and safety of the elevator. Thus, through continuous experimentation and simulation analysis, the elevator structure design can be repeatedly optimized, ultimately achieving the goal of advancing elevator lightweight technology.

4. The lightweight design of intelligent elevator under the background of green manufacturing

4.1. Structural analysis and optimization design of elevator car system

The lightweight design of the elevator car is an important part of the lightweight design of the intelligent elevator under the background of green manufacturing, including the elevator car material and the overall optimization. On one hand, the common lightweight materials are mainly aluminum alloy honeycomb panels, carbon fiber composite materials, etc., which can replace the traditional elevator car materials (such as glass, steel, etc.), which is conducive to reducing the weight of the car. In addition, the car wall panel is mainly used for space isolation in the use of the elevator car, which cannot afford the main function of carrying and its material can be relatively large lightweight design application value. For example, stainless steel composite panels made of carbon steel and stainless steel cladding can be used to reduce the waste of unnecessary material resources. On the other hand, for the optimal design of the elevator car structure, it can be designed to be streamlined. In this way, the piston resistance during the operation of the elevator can be greatly reduced, which is conducive to saving energy.

4.2. The selection of lightweight high-strength materials to design the elevator traction wire rope

Material selection is a key step in the lightweight design of elevator traction wire rope. The traditional traction wire rope generally uses high-strength heat treatment of alloy steel material, although it has high strength and wear resistance, but there are also shortcomings such as large weight. Therefore, to reduce the weight of the elevator, in the lightweight design of the intelligent elevator, the use of new lightweight materials with high strength, low density, good wear resistance, and other characteristics can be considered, such as carbon fiber composite materials, high strength nickel-based alloy, etc., which can significantly reduce the weight of the traction wire rope, improve the operating efficiency and energy saving level of the elevator [13].

Among them, in the structural design of the traction wire rope, hollow structure, multi-strand rope, and other lightweight design schemes can be used. The trailing wire rope of the hollow structure can not only reduce the amount of material, but also improve the torsional stiffness and wear resistance, and has a better lightweight effect. The multi-strand rope design can combine the multi-strand wire rope, improve the bearing capacity and fatigue life, but also reduce the weight, which is conducive to optimizing the operating efficiency of the elevator.

In terms of performance optimization, simulation analysis, and experimental verification technology can be used to evaluate the operating effect of different lightweight design schemes. For example, by using finite element analysis and other simulation methods, the force conditions of the elevator traction wire rope can be simulated under different circumstances. This allows for the evaluation of its strength, stiffness, and other performance indicators. Additionally, experiments can be conducted to test the feasibility and safety of the intelligent elevator lightweight design, providing reliable technical support for the practical application of the elevator traction wire rope.

4.3. Improving the elevator drive control system with the help of intelligent control technology

For the improvement and optimization of the intelligent elevator drive control system, intelligent and digital technology can be used to monitor the change of the elevator weight balance in real time and it can also reduce energy consumption and effectively improve the elevator transmission efficiency. Among them, for the design of the elevator lightweight control system, the integrity of the elevator structure should be taken into account, including the layout structure and connection of various components, to effectively improve the stability and reliability of the elevator drive control system. Specifically, in this process organization, advanced control strategies, such as speed control, position control, load distribution, etc., can be used to ensure the safety of the elevator under the premise of improving the efficiency of elevator operation and energy saving [14].

With the continuous development and popularization of the Internet of Things and artificial intelligence technology, the introduction of intelligent control technology in the elevator lightweight control system can be considered, such as machine learning algorithms and big data analysis, to further improve the intelligent level and predictive performance of the control system, to promote the elevator operation efficiency, energy saving and safety [15]. For example, by writing the control algorithm and logic of the elevator operation, the optimization and upgrading of the elevator scheduling, fault detection, and maintenance functions can be achieved, to improve the safety and reliability of the elevator drive control system.

4.4. Relying on safety evaluation and testing to promote elevator lightweight

The safety evaluation and test of elevator lightweight design need to use computational simulation, laboratory test, field test, and safety evaluation methods to ensure the reliability and safety of lightweight design. At the same time, the relevant safety standards and specifications need to be strictly abided to ensure that the lightweight design is always in line with the relevant regulations.

First of all, when using computer simulation software for simulation and data analysis, attention should be paid to the evaluation of the impact of lightweight design on the strength, stability, and safety of the elevator structure, identify potential safety risks, and make targeted improvements by simulating the operation of the elevator under different conditions in a virtual environment. Secondly, in static and dynamic load tests, vibration tests, and other laboratory assessments, it is essential to verify the reliability and safety of the intelligent elevator lightweight design. This can be done by physically testing the elevator components and the entire system to confirm the accuracy of the simulation results. Based on these tests, the actual performance of the elevator lightweight design can be objectively evaluated.

Then, field experiments are carried out on the elevator lightweight design, that is, by carrying out the elevator lightweight application test in the actual operating environment, observing its performance and safety under different conditions, and modifying and improving the elevator lightweight design scheme according to the field experimental results. Finally, risk assessment and safety analysis are carried out on the lightweight elevator design, to identify potential safety risks and formulate countermeasures. In this process, safety standards and specifications are used to evaluate the lightweight design to ensure that it meets the relevant safety standards and regulatory requirements.

5. Conclusion

In conclusion, in the context of green manufacturing, strengthening the design and application of elevator

lightweight through intelligent, digital, and other technological means can effectively reduce energy consumption during elevator operation, lower manufacturing and maintenance costs, and enhance the efficiency and accuracy of intelligent elevator green design. This approach is an effective way to promote the advancement of industry technology. Specifically, relevant enterprises can achieve intelligent elevator lightweight design by conducting structural analysis and optimization of the elevator car system, selecting lightweight, high-strength materials for designing the elevator traction wire rope, and utilizing intelligent control technology to enhance the elevator drive control system. Additionally, safety assessments and testing can be relied upon to promote the successful implementation of elevator lightweight.

Disclosure statement

The author declares no conflict of interest.

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