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Brief Analysis on Development Status of New Elevator Buffer

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Abstract

In the TSG T7001-2023 "Regulation for Lift Suspervisory Inspection and Periodical Inspection" released in 2023, it is proposed to conduct video recording of non-metallic nonlinear energy storage buffer tests during regular inspections, indicating that the country is increasingly paying attention to elevator safety. Starting from the working principle and structural type, this article provides a brief analysis of the current new elevator buffer, elaborates on the development status and trends of the new buffer, and provides some reference for the future development of buffers.

Keywords

TSG; Elevator safety; Elevator buffer; Development status and trends.

1. INTRODUCTION

As a major user and producer of elevators, the quality and safety of elevators in China have always been a focus and priority for the general public and society. With the rapid development of the elevator industry, the accident rate per 10000 units and the number of casualties have decreased, and the overall safety situation of elevators is stable. According to a notice from State Administration for Market Regulation, the number of elevators has increased from 7.8655 million to 10.6298 million from 2021 to the end of 2023. With the total number of elevators in China reaching new highs, the number of old elevators is gradually increasing, and elevator safety accidents are becoming more frequent, attracting widespread attention from society.

State Administration for Market Regulation issued a notice on June 18, 2023, entitled "Three Year Action Plan for Building a Bottom for Elevator Safety (2023-2025)" (hereinafter referred to as the "Plan"), which requires further improvement of the quality and safety level of elevators to ensure the safe and reassuring use of elevators by the people. The Plan proposes key tasks for promoting the high-quality development of the elevator industry, requiring adherence to the principle of leading from the source, supporting elevator production enterprises to strengthen research and development, improve the safety and reliability of elevator products, and fundamentally enhance the quality and safety level of elevators. In the newly released TSG T7001-2023 in 2023, special requirements for audio and video recording of buffer (non-metallic material nonlinear energy storage type) tests were put forward during regular inspections, indicating the importance that the country attaches to elevator safety. The composition of the elevator has multiple safety protection devices, among which the buffer is the last checkpoint. As a safety component, its normal operation plays an important role in the safe operation of the elevator. In this article, the author will briefly introduce the types and forms of buffers, and analyze the current development trends, hoping to provide some reference value for the future development of buffers.

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2. WORKING PRINCIPLE AND CLASSIFICATION OF BUFFERS

The working principle of a buffer is energy absorption and release. The buffer absorbs the kinetic and potential energy generated by the car or counterweight, and converts it into safe energy for release. During the operation of the elevator, when other safety components fail and cause the car or counterweight to fall freely beyond the operating range, the buffer plays a role in slowing down and stopping, absorbing the kinetic and potential energy generated by the car or counterweight, thereby avoiding the elevator's squatting and toppling, and ensuring the safety of passengers' lives and property.

Buffer is generally divided into energy storage type buffer and energy dissipation type buffer according to the way of absorbing energy[1]. Energy storage buffers are further divided into linear and nonlinear types, with linear buffers represented by spring buffers, nonlinear buffers represented by polyurethane buffers, and energy dissipation buffers represented by hydraulic buffers. The spring buffer is composed of a buffer rubber pad, a buffer seat, and a cylindrical spiral spring seat. Its characteristic is rebound. Through the elastic deformation of the spring, the kinetic or potential energy of the elevator is converted into the elastic potential energy of the buffer, generating the reaction force of the spring to slow down and stop the elevator; Polyurethane buffer utilizes the microporous bubble structure of polyurethane material to absorb energy and buffer, acting as a spring with multiple airbag damping during impact; The hydraulic buffer is composed of a buffer pad, a reset spring, a plunger, an annular throttle hole, a variable rod, and a cylinder body. When subjected to the impact of the elevator, the buffer is stable, and the impact kinetic energy is converted into thermal energy through the small hole throttling effect. The auxiliary spring can absorb the first impact.

Figure 1. Energy consuming hydraulic buffer

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Figure 2. Energy storage type nonlinear polyurethane buffer

Traditional buffers have some structural defects and lack maintenance in use. Fig. 1 shows an energy consuming hydraulic buffer. It can be observed from the figure that the impact rod used to trigger the electrical switch of the hydraulic buffer has bent and cannot work normally. Under normal circumstances, when the hydraulic buffer is compressed to the specified stroke, the electrical device for verifying the plunger reset of the hydraulic buffer should act accordingly, thereby disconnecting the safety circuit. However, the bent impact rod cannot move correctly with the compression of the buffer, resulting in the failure of the electrical device for verifying the plunger reset. The reason for this problem is that the brake test was conducted in the previous year, and during the loading and unloading process, the car settlement was large, compressing the buffer. In addition, the installation position of the impact rod was incorrect, causing the impact rod to bend. Fig. 2 shows an energy storage type nonlinear polyurethane buffer. It can be observed from the figure that the polyurethane buffer located on the counterweight side has aging and damage issues, which poses a significant safety hazard during normal operation. In summary, we can find that traditional buffers have more or less shortcomings and safety hazards, which have significant practical significance for the design and development of new buffers.

3. THE CURRENT DEVELOPMENT STATUS OF NEW BUFFERS

3.1. Buffer based on magneto rheological technology

Magnetorheological fluid is an emerging intelligent material, originally invented by two American scientists Winslow and Rabinow. However, there were bottlenecks in the research process and its development was postponed. Later in the early 1990s, scientists rediscovered some characteristics of magnetorheological fluid and began to re-examine and promote the development of related equipment. China's research in the field of magnetorheological fluids is relatively lagging behind, but some scholars have made achievements in the preparation of magnetorheological materials and rheological mechanisms.

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Lai Xuhua et al. [2] designed a magnetorheological fluid buffer that integrates a magnetic induction ring and a magnetic blocking ring. The magnetic circuit was optimized to reduce the impact of magnetic leakage while increasing the effective length of the damping channel, thereby improving the efficiency of the buffer. By analyzing some physical properties of magnetorheological fluid, adaptive and stepless adjustment of damping force of the buffering device has been achieved, with wide applicability and effectiveness in elevators at various operating speeds, improving the smoothness and stability of the buffering process.

Wang Yangyang [3] integrated magnetorheological technology into elevator buffers by analyzing the performance of magnetorheological fluids, changing the uncontrollable state of traditional buffers during operation. During the operation of the buffer, the magnetorheological fluid is controlled to achieve constant damping, allowing the car buffering process to slow down smoothly, improve the efficiency of the buffer, and avoid unnecessary personal and economic injuries. During the research process, Wang Yangyang constructed a mathematical model of the magnetorheological fluid buffer based on the constitutive relationship of different fluids. He completed the structural design of the magnetorheological fluid buffer according to the design requirements of the buffer, and used ANSYS software to perform finite element analysis on the magnetic circuit of the magnetorheological fluid buffer, calculating the current variation curve in the magnetic field and the high fitting formula. Finally, the impact test of the magneto rheological fluid buffer was simulated in Simulink, and the simulation verified that the magneto rheological fluid buffer can effectively slow down the impact speed of the car.

Shi Xin et al. [4] replaced the hydraulic oil in traditional energy consuming buffers with magnetorheological fluid, improving the buffering efficiency of the buffer in collisions. By analyzing the principle of magnetorheological fluid and using ANSYS software to calculate the magnetic field strength, the deceleration trend of the car under different working conditions is obtained by changing the working current. The factors affecting the efficiency of magnetorheological fluid buffers are analyzed, providing a new method for evaluating the working performance of magnetorheological fluid buffers.

3.2. Buffer device with airbag

Huahong et al. [5] analyzed the shortcomings of traditional buffers with safety airbags and designed a buffer device with safety airbags based on environmental development direction and market demand. The liquid buffer in the traditional buffer was replaced with gas, and a real-time monitoring device was embedded to observe the relevant status of the elevator, so as to adaptively adjust the amount of gas in the buffer device to control the buffering force generated during collision, reduce the harm caused by car squatting, and achieve the effect of "slow landing" of the car. At the same time, the use of gas as a buffer medium solved some oil pollution and contributed to environmental protection.

Yao Linqi [6] designed a safety airbag that can fit into the arc-shaped groove of the pit at the bottom of the car. There are arc-shaped sliding blocks and horizontal buffering devices distributed around the arc-shaped groove of the pit. When the car collides with the arc-shaped groove due to squatting, the safety airbag and various horizontal buffering devices of the pit can share the impact force and achieve the expected effect. This design has a small rebound force, simple structure, and is easy to maintain on a daily basis. At the same time, a speed sensing device connected to the MCU module is equipped in the car, which can monitor the elevator speed in real time to change the gas inventory in the airbag.

3.3. Side pressure buffer device

Huang Xu et al. [7] developed a lateral pressure type elevator buffer device based on actual conditions. Multiple buffers arranged longitudinally are installed on the inner wall of the pit buffer base, and a conical triggering device is installed at the bottom of the elevator. When the

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elevator car falls, the conical triggering device falls into each layer of buffer and compresses it laterally, absorbing the energy generated by the stall of the elevator car, causing it to decelerate smoothly, and finally stopping the elevator car, achieving the effect of protecting the stall elevator and reducing personal and property losses.

3.4. Foam aluminum column buffer device

Lu Ding [8] took foam aluminum, a new metal material, as the research object. By analyzing the performance characteristics of foam aluminum, he designed a buffer energy absorption structural device with foam aluminum as the core cylinder, and carried out mechanical characteristics research and influence factor analysis under axial impact. He further gave the mathematical model of static and dynamic mechanical characteristics of foam aluminum core cylinder under comprehensive factors. With the help of ABAQUS finite element model software, he verified the feasibility of the buffer energy absorption structural device with foam aluminum as the core cylinder under axial impact, and can effectively brake elevators that exceed 5 times the rated speed.

3.5. Other buffering devices

Xu Guangjun et al. [9] invented a buffer device integrated with the steel structure of a building. A buffer plate with a buffer pad above and an auxiliary buffer device below is set up in the pit. Multiple telescopic rods are designed on the well wall. Through this design, the buffering effect of the buffer device is improved, preventing it from quickly rebounding after receiving impact, which has a certain practical effect. Sun Fenfen [10] invented and designed a protective device that combines multiple buffering devices, using the cooperation of multiple buffering devices to reduce the energy generated during elevator falls, ensure personal and property safety, and reduce the risk of major accidents caused by car falls. Li Beilei et al. [11] invented a multi modulus elevator safety buffer device, which uses airbags, corrugated pipes, and multiple oil cylinders in the pit to achieve smooth buffering during elevator squatting and protect passengers inside the elevator.

4. CONCLUSION

With the rapid development of China's economy, urbanization means a continuous increase in the total number of elevators, while the social attention to elevator safety is increasing, and the requirements for elevator safety components are also higher. As the last safeguard in elevator safety components, conducting in-depth research on it has significant practical significance.

This article introduces the development status and trends of various new elevator buffer devices, discusses the principles and structures of each new buffer device, and elaborates on the characteristics of each new buffer device. With the continuous development of new buffering devices, more in-depth research is needed to gradually transition from a safe and stable type to an economical and environmentally friendly type of elevator buffering device, improve the safety of elevators, and promote the high-level development of China's elevator industry.

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