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Development of a 125% Load Brake Test Instrument for Elevator

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Development of a 125% Load Brake Test Instrument for Elevator

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Abstract. In order to solve the problem of elevator braking test inspection, this paper combs the requirements of relevant national standards and inspection rules on braking performance, and develops an elevator braking test inspection instrument. With the help of the instrument, the elevator braking effect can be expressed quantitatively, and the inspectors can conveniently judge whether the braking test results meet the requirements of elevator inspection rules remotely. A way to standardize and rationalize the test is given.In order to solve the problem of elevator brake test inspection, this paper sorted out the national standards and inspection rules on braking performance, and developed an instrument of elevator brake test inspection. With the help of the instrument, we could quantitatively give the expression on the elevator braking effect, and the inspectors can conveniently judge whether the braking test results meet the requirements of the elevator inspection rules in the remote.

1. Introduction

According to the Circular of the State Administration for Market Regulation on the Safety situation of Special Equipment in China in 2020, there were 7,865,500 elevators registered, and 107 special equipment accidents occurred, of which 25 were elevators, accounting for 23.36% of the total accidents. According to relevant statistical analysis in recent years, 85% of passenger death in vertical elevator accidents is caused by unexpected movement of elevator car, which lead to shear, extrusion and falling, and the main reason for the above accidents is brake failure or insufficient braking force.[1]

In research of the elevator accident case analysis and risk, as well as the elevator on technical development, the former General Administration of Quality Inspection and Quarantine issued implementation made by General Office of aqSIQ < Regulations of Elevator Inspection and Regular Inspection>, including 6 safety technical specification noticed on no. 2 modified issues (referred to as the "inspection regulations"), it is required to add brake test items in elevator inspection. In view of the inspection requirements, the key parameters of the car deceleration is difficult to measure, at the same time, the project inspection workload is heavy, so the inspection personnel are generally confused by the lack of inspection equipment. Therefore, it is very urgent to polish the test method and corresponding equipment.

By analyzing the mechanism of elevator brake test, this paper summarizes the internal characterization index of brake test, and develops a set of brake test inspection instrument, we hope that this instrument can quantitatively analyze whether the elevator brake test meets the requirements of "Inspection regulations", and reduce the workload of inspectors.

2. Elevator brake test requirements

2.1. Requirements of elevator brake test in Inspection Regulations

For the traction passenger elevator, first of all, the area of the car is strictly limited, which controls the number of passengers from the spatial position. Secondly, the elevator is required to set up overload protection device, which prevents the normal start when it reaches to 110% of the rated load. The inspection requirements of the brake test are as follows: when the car goes down at the normal running speeds without the motor and brake, it can carry 125% of the rated load capacity maximally, and the brake should be able to stop the driving host, and the car shall have no obvious deformation and damage after the test. In this way, enough allowance is given for the design of the working brake, and the safety of passengers can be guaranteed theoretically under the worst working conditions.[2]

2.2. Technical requirements for elevator braking in standard

"Safety Code for Elevator Manufacturing and Installation" GB7588-2003 (referred to as the "Standard")[3] has the following requirements for elevator braking performance:

2.2.1. Running downward with rated speed

Operating the brakes shall stop the tractor when the car is carrying 125% of the rated load and moving downward at rated speed. In such cases, the car should not decelerate beyond the deceleration caused by the safety clamp action or striking the buffer.

2.2.2. In the case of free fall

In the case of free falling, the average deceleration rate of the car with rated load is $0.2g_n$ to $1.0\ g_n$ when the progressive safety clamp is moving.

2.2.3. Energy dissipation buffer

The buffer should conform to the principle that when a car with rated load falls freely and hits the car buffer at 115% of the rated speed, the average deceleration during the buffer operation should not be greater than $1g_n$.

The deceleration time should be no more than 0.04s when costing $2.5g_n$ or more.

2.3. The analysis

Comprehensive comparison of the requirements of "Inspection Regulations" and "Standards" for brake test can be concluded that the inspection item is in essence to verify the elevator braking ability and effect. In the current inspection, it is more judged by the inspectors' experience for the braking effect, we use marking method, which is a simple way to measure the stop distance to find whether it meets $0.2g_n$~$1.0g_n$ after comparing with the standard requirements of the value, However, it is impossible to determine the requirement that the deceleration time above $2.5g_n$ should not be greater than 0.04s. And the way of marking, in the elevator with no room or the elevator with high speed, the judgment of the brake point completely depends on the reaction of the inspector, and it would be cost large error relatively.

In order to meet the requirements of the standard brake performance finally, so as to achieve improving the accuracy and effectiveness of the test data and reducing the error caused by subjective reasons at the same time, this paper research and develop brake test testing instrument from the combination with average deceleration, maximum deceleration, modern network and computer technology.

3. Development of testing instruments

The system integrates the perception layer, network layer and application layer of the Internet of Things structure, and the basic architecture is shown in Figure 1. Among them, it involves hardware composition, software development, data transmission&storage, analysis and application.

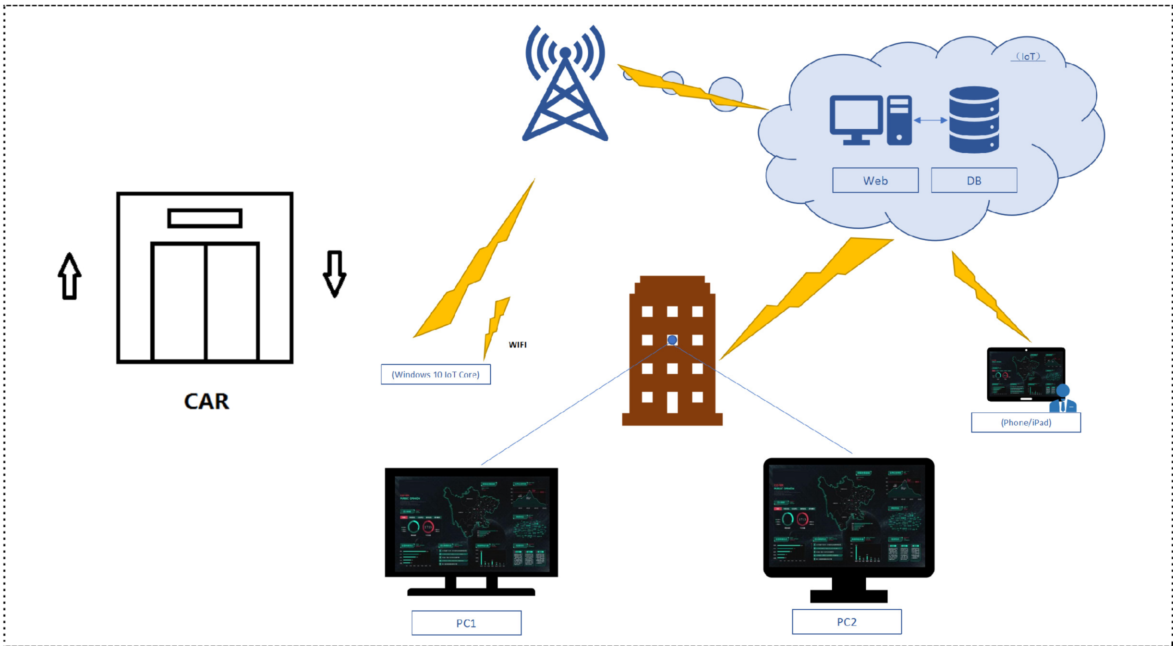

Figure1. Instrument architecture diagram

3.1. Hardware components

The hardware of the instrument is composed of the camera installed in the car, the machine room, and the inspection instrument terminal.

Based on the main data collection is made by acceleration. Now there are mature acceleration sensors on the market. We will integrate the acceleration sensors into the inspection instrument terminal.

3.2. Software selection and development

The selection of software technology should be considered comprehensively in many ways, including the combination of hardware equipment and operating system; the combination of software and operating system; the combination of software and Internet of Things (IoT), and software engineering. The operating system of the inspection instrument terminal is Windows 10 IoT core edition, and the software is based on. NET/C# custom development.

We introduce the Azure IoT Center to the long-term solution for IoT services, it is a comprehensive and mature IoT Center. The ecological side is equipped with common cloud services, Iot centers, Iot device development languages&communities, database systems, and more. Based on the completeness of the scheme, the development cycle is 20% shorter than other schemes, benefiting from more direct callability of common modules, visualization of configuration management and debugging of common problems, and visualization of performance monitoring and debugging. In addition, there is integration with the third party (sensors, video equipment SDK), Microsoft has the correlation and inertia of all technologies with upgrade background services and monitoring analysis software, which to achieve the Internet of things more widely and deeply enabling in the inspection process of elevator equipment.

3.3. Software selection and development

In the field test, the installation and maintenance personnel can adjust the instrument with the support foot, and place it at the center of the car to the ground. We installed a camera in the face of traction machine in the computer room, and use it to record test of traction machine braking condition; we installed a camera in the the capsule to confirm the weight and when the test capsules can change, this camera can synchronizes the video data to the local storage of the inspection instrument terminal through connecting with the inspection instrument terminal. Equipment installation is simple without debug, which can be delivered to the site installation and maintenance personnel to complete instead of intervention of inspection personnel.

At the beginning of the test, it just need to click the start button manually on the screen of the instrument, and the operator exits the car to ensure safety, then the operator controls the elevator to run down from the top terminal station, and then makes an emergency stop. The software will automatically make the judgment on running status. At the beginning, the real-time acceleration data of the elevator during the braking process was record by time unit of 0.01s, and the elevator can stop collecting data after the software automatically stop, then the instrument will collect data through analysis and standard comparison, as shown in figure 2, the data includes in stopping distance, average deceleration and breaking time, and finally to find the test results whether it is qualified or not. If the test is not qualified, the field operator can query the brake data, and adjust the brake to prepare for the next test. At the same time, the instrument will automatically upload the test data and video as shown in FIG. 3 to the cloud server, and inspectors can query the data and video of the test results from the server without going to the scene, and make a judgment on the project. At the same time, the data stored in the server can provide support for the later analysis of brake usage.

Figure2. Partial elevator braking test system

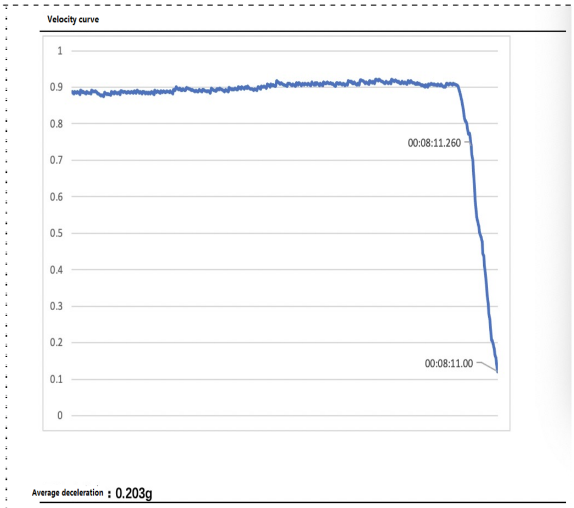

Figure3 Braking test curve

3.4. Verification of test data

In order to test the reliability and accuracy of the instrument, we selected 5 elevators for braking test, and compared the instrument measurement data with the traditional manual inspection data, than get the results as shown in Table 1.

Table 1 Comparison of measurement data

	Stopping distance（mm）			Average deceleration（g_n）			Maximum deceleration（g_n）		
	Instrument to measure	Artificial measurement	difference	Instrument to measure	Artificial measurement	difference	Instrument to measure	Artificial measurement	difference
Elevator#1	203	190	-13	0.203	0.217	+0.014	0.3347778		/
Elevator#2	247	262	+15	0.529	0.498	-0.031	0.7603149		/
Elevator#3	241	228	-13	0.541	0.573	+0.032	0.81561279	You can't measure	/
Elevator#4	226	245	+19	0.578	0.533	-0.045	0.7611694		/
Elevator#5	183	212	+29	0.714	0.616	-0.098	0.7974243		/

As shown in Table 1, elevator no. 5 has the biggest stopping distance deviation of 29mm, and Elevator No. 1 and Elevator No. 3 have the smallest deviation of 13mm. The average deceleration deviation of elevator No. 5 is 0.098g_n, and that of Elevator No. 1 is 0.014g_n. The maximum deceleration obtained in the instrument test is 0.8156279 g_n of no. 3 elevator, and the rest elevators are also meet the standard requirements of more than 2.5 g_n and less than 0.04s. The test results obtained by the two test methods are all qualified, and the error is within the acceptable range. In addition, the maximum deceleration cannot be measured by manual measurement, therefore, the conclusion of instrument measurement is more scientific and accurate.[4]

4. Conclusion

Based on the requirements of relevant national standards and inspection rules for braking performance, an elevator brake test instrument is developed. The instrument is convenient to be installed and can be used by non-professionals, which reduces the workload of inspectors.

The instrument can quantify the performance of the elevator brake test, and the output data is intuitive and easy to be read, which can make the test results more accurate and reliable. The instrument usage can avoid the inspection risk brought by the subjective judgment of inspectors, and give a way for the test of standardization and rationalization.

- The data measured by the instrument is rich, including a variety of real-time elevator operation information, such as stop distance, deceleration, average deceleration, elevator speed and so on. Through further data analysis, we can predict the braking force decline or failure of the brake. Thus, it can provide the test method and basis for the scrapping judgment of brake in the national standard "Technical Conditions for scrapping of Main Parts of Elevators" (GB/T 31821-2015).[5]

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