A Device Used for The Elevator Shaft Wall out of Tolerance Measurement Based on The Laser Ranging Technology

Yang Lin*
Dalian Institute of Special Equipment Inspection and Testing Research Co., LTD, Dalian 116013, China
*Corresponding author e-mail: y19491010@disei.com

Abstract. The national safety technical specifications and standards have clear provisions on the distance between the elevator car and the well wall facing the car entrance. Current measuring methods are lower measurement efficient and accuracy, and poor repeatability. With the increasing number of elevators, this traditional method is far from meeting the requirements of practical work. This paper studied on the Laser ranging technology applied to the distance measurement aiming to overcome those problems. The new measuring equipment was consisted of the laser ranging module, rotary encoder and Bluetooth module, which can measure and record all data related to the distance between the car and the car entrance shaft wall. The advantages of the new device are higher repeatability and reliability, which greatly improve the measurement efficiency. It is suitable for measuring the distance between elevator car and shaft well of high-rise building, thus the inspectors can be free from the heavy work of measurement.

Keywords: Elevator Inspection, Laser Measure, Shaft Wall

1. Introduction
The special equipment safety technical specification TSG T7001-2009 "Elevator Supervision inspection and Periodic Inspection Rules - Traction and Forced Drive Elevator" stipulate “The distance between the car and the well wall facing the car entrance shall not be greater than 0.15m, and this distance may be increased to 0.20m for freight elevators with a local height less than 0.5m or with vertical sliding doors. This distance is not limited if the car is equipped with a mechanically locked door and the door can only be opened in the unlocked area.”[1] shown in Fig. 1.
Fig. 2 The flow of traditional measurement

There are two general test methods for the above regulations. The first way is two inspectors were
in two separate spaces. One inspector reads the data directly inside the elevator car, while another
inspector facilitate the work at the top of the elevator car. In order to avoid the safety hazard of two
inspectors in two separate spaces, the other method is setting a measurement reference point at the top
of the elevator car and measuring the distance between the elevator car side and the shaft wall. The
measurement process is shown in Fig. 2.

Fig. 3 The structure of the host

2. Hardware Design

The measurement system adopts modular design with two microprocessors as the core. The module
of the elevator car roof detection equipment (called the host) is shown in Fig. 3. It is composed of the
ranging rotary encoder, the wireless modem, the operating display of human interaction and the SD
card etc.
The module of the inside detection equipment (called the extension) is shown in Fig. 4, which is composed of one processor, two-channel laser ranging sensor and wireless modem etc.\(^{[8-10]}\).

![Fig. 4 The structure of the extension](image)

The main function of the extension is measuring the distance between the detection equipment inside and the shaft well by the laser ranging module, and transmitting data to the host by Bluetooth module. Two-channel laser measurement module was adopted in the inside detection equipment which enlarges the detecting range. The frequency of data collection per unit time was increased by software which can drastically reduce the false alarm or missing alarm.

The function of the host is receiving the data from the extension by the Bluetooth module, measuring the running speed of elevator car by rotary encoder and obtaining the distance measurements in the vertical direction indirectly. Meanwhile the host can also judge alarm, store data and display the test result both horizontally and vertically.

3. Software Design

3.1 The Software System Flow

The host and the extension should be connected by Bluetooth immediately after power on. The host receives the data frame from the extension then unpacks and restores them. Convert the velocity data into the distance data in the vertical direction, which collected by the encoder mounted on the host. After getting the horizontal and vertical data, make logical decisions based on rule checking, then complete the alarm and related storage work is converted.

3.2 Rules Check

According to the special equipment safety technical specification TSG T7001-2009 "Elevator Supervision inspection and Periodic Inspection Rules - Traction and Forced Drive Elevator" 3.7. “The distance between the car and the well wall facing the car entrance shall not be greater than 0.15m, and this distance may be increased to 0.20m for freight elevators with a local height less than 0.5m or with vertical sliding doors. This distance is not limited if the car is equipped with a mechanically locked door and the door can only be opened in the unlocked area.” We classify the out-of-tolerance problem of the shaft well into two types.

The first case is that the distance between the car and the well wall facing the car entrance is greater than 0.20m at any time. The buzzer gives an alarm and the host stores the relevant data. The second case is when the distance is greater than 0.15m and the height of the car is greater than 0.5m. The buzzer gives an alarm and the host stores the relevant data. The Schematic diagram of alarm situation is shown in Fig. 5.
4. Measuring Method

The extension should be installed and fixed in the elevator car. The host should be handheld or installed on the top of the car. The rotating head of the rotary encoder is in good contact with the overspeed governor rope or guide rail. During the measurement, turn on the elevator bypass of the car door and open the car door completely. That can avoid the mutual scratch come from the door knife and door lock rollers. Then make the elevator downward and measure it.

The installation distance of the extension should be determined when the extension is installed. The first step is to determine which distance is the smallest between the elevator shaft interior surface and the car floor, door frame, and car door, because different car has different structure. The way to do that is selecting any floor station which is not the bottom end station, and measuring the distance between the car sill and the landing sills marked m1, measuring the distance between the door frame and the landing sills marked m2, measuring the distance between the car door and the landing sills marked m3. Then put the measurement device in the elevator car and measure the distance between the device and the landing sills marked m0. The maximum value of the difference between m0, m1, m2 and m3 is taken as the horizontal reference distance which marked m. The measurement method is shown in Fig. 6. Input the data of the horizontal reference distance and elevator maintenance speed into the Single-Chip Microcomputer. The distance between the device and the obstacle marked l can be obtained with the maintenance speed. The distance between the car and the well wall facing the car entrance (l-m) was reached by the controller internal operation. If the distance is greater than 0.2m, or in the range of 0.15 - 0.2m, and the product of continuous time and maintenance speed is greater than 0.5m, an alarm will be sent through the buzzer, at the same time the real-time distance will be displayed and the maximum distance will be locked.
5. Conclusion
This paper studied on a newly development device with higher measurement efficiency than traditional method. There is no need to stop of the elevator that can greatly reduce the loss of elevator components. Meanwhile, using the Bluetooth module for data transmission instead of inspector reads the data directly inside the elevator car greatly reduced the risks and hidden dangers of measuring personnel in measuring operation. And the equipment is small in size, light in weight, easy to carry, and easy to operate. The last but not the least, the developed device can perform historical query on the measured result data, and it can store all the non-conforming data, including the non-conforming area size, the location of occurrence, the degree of severity, etc. These data are not only of great significance when the inspection report is issued, but also of great value to the rectification work of the using unit.

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