Design of On-line Detecting Device for Groove Wear of Elevator Traction Wheel

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Abstract. After the wear of elevator traction wheel, there is a traditional detection method which can measure the geometric dimensions of wheel groove. But this method has low measurement accuracy and cannot accurately reflect the actual profile of wheel groove. By means of the machine vision inspection technology, the profile of the traction wheel groove can be measured, a new detection method is proposed in this paper, and the corresponding measuring device is designed in detail. At the same time, with help of the computer simulation, the processing of the work piece image is used. In this method, the size and profile of the wheel groove of the traction wheel can be measured more accurately and quickly to reflect the actual wear value of the wheel groove.

Keywords: Elevator traction wheel; Groove wear; On-line detection; Device designing.

1. Introduction

As the main vertical transportation tool in the building, the main structure of the elevator is the connection between the car and the counterweight device through wire rope, which drives the traction wire rope to control the operation of the elevator. The wire rope is wrapped on the traction wheel, one end hangs the car, the other end hangs the counterweight device, and the force of friction between the traction wire rope and the traction wheel groove drives the car up and down with the rotation of the traction wheel. The elevator is driven by wire rope pressure and friction between wire rope and wheel groove(Xu 204).

With the increase of the service life of the traction wheel groove, the groove of the traction wheel will wear. With the increase of the wear value, the size of the wheel groove will change, reducing the force of friction between the traction wire rope and the wheel groove reduced, car sliding accident could happen(Ding 77).

According to Elevator Technical Maintenance Standard, when the groove wear value of the traction wheel exceed limiting value, it is necessary to repair or replace the traction wheel in time. If it is not repaired or replaced in time, it will affect the safe operation of the elevator and the personal safety. At present, the detection method of traction wheel wear value is very low efficiency which can not realize on-line measurement, and the detection operation process is complex, the universality and applicability are weak, and the measurement accuracy is very low too(K 117).

2. The Traditional Detection Method and Replacement Standard of Traction Wheel

Now, the universal method used by the examiner in the actual detection is Vernier caliper measurement. But relative to some specific wear forms, there will be some corresponding measurement methods(Fig.1). This method is mainly used to measure whether the depth of each wire
rope declining groove is consistent, or whether the wear degree is consistent (Zhao 36). Firstly, the traction machine stops, and removing the wire rope on the traction wheel (Chen 112). Secondly, putting standard steel beads for testing into the wheel groove, and making the right-angle gauge close to one side, on the other side, reading different wear value between each wheel groove. In addition, small gap between the wire rope and the bottom of wheel groove is required. The gap shall not be less than 1 mm, fine wires of 1 mm diameter are used to measurement of small gap (Yang 63). If fine wire can not pass through the gap between the bottom of the wheel groove and the wire rope, the gap between the wire rope and the bottom of the groove is too small. So it is necessary to repair the groove profile of the traction wheel, or replacing the traction wheel.

![Figure 1](image1.png)

Figure 1. Method for measuring the diameter difference of groove of traction wheel.

According to the technical conditions of scrapping for the main parts of the elevator (GB/T 31821.2015), it is known that the replacement criteria for traction wheels are as follows:

One of the following cases shall be deemed to meet the technical conditions of scrapping:

a) Traction force reduced by wheel groove wearing can not meet requirements of GB 7588.2003 9.3 a) or b), b) Defect or abnormal wear of wheel grooves, c) There is a crack in the traction wheel.

3. Main Structure Design of Detection Device

3.1. Selecting of Main Dimensions of Detection Device

3.1.1. Length

The length of the detection device should make the outer contour of the traction wheel just between the light source and the camera lens. At the same time, the camera's field of view can also be photographed within the bottom of the groove at least 5 mm. Dimensional relationship (Fig.2). Calculation as follows:

![Figure 2](image2.png)

Figure 2. Relationship between Length and Dimension of Device.

To get the camera a full wheel profile image, set light panel thickness of 10 mm, lens and camera assembly length of 90 mm. The design length of the device meets the following dimensional relationships.

\[
237 + 10 + 90 = 337 \text{mm}
\]
3.1.2. Height and width

The width of the camera plus the thickness of the support material and the margin of the side seam, Height (Fig. 3).

\[ 50.4 + 2 \times 2 + 1 \times 2 = 56.4 \text{ mm} \tag{2} \]

Figure 3. Diagram of the height dimensions of the device.

As shown in Fig. 3, the green line is the frame of the device, the height of the LED illumination plate on the left side is 52 mm, the camera holder on the right side is 86 mm. Base plate width is 10 mm.

4. Detailed Design of the Installation

4.1. Arrangement of LED Lighting Panels

Lighting panel area is 50*50 mm, no lamp bead on edge, a bead of light is inside the lighting board every 8 mm, alignment effects (Fig. 4).

Figure 4. Lighting panel.

4.2. Hand Grip

Hand grip design length 150 mm, because the traction machine is well assembled. In order to achieve the purpose of online measurement without removing the traction wheel, a proper length grip should be designed in a narrow operating space. At the same time, the grip should be ergonomic, a ball hinge connection between the grip and the detection rack, in the actual detection, the examiner can work at the most convenient angle, a rubber pad is wrapped on the handle surface for anti-slip, detailed structure (Fig. 5).

Figure 5. Ball hinge connection.

4.3. Design of Regulating Structure

Due to different types of traction wheel sizes, the frame of the detector is designed as slide rail type, such it can adjust the length of the device according to the actual size of the traction wheel. After the length is adjusted, the fixed screws on the slide rail should be tightened. In order to obtain the best view, the camera vision can be adjusted by rotating the adjusting screw under the camera.
4.4. Design of Other Structures

The two ends of the rack are also designed with contour supports which are used to withstand the external contour bus of traction wheel, a resin layer is attached to the surface of the contour supports to prevent the rack from sliding in direct contact with the traction wheel, so that the detection device installation and location are more stable.

The camera fuselage is provided with a control and transmission interface that can be connected to a micro storage device or computer, it is easy access to test results. The actual model is shown in Fig. 6 and Fig. 7.

![Figure 6. Model of detector.](image1)

![Figure 7. Detect Effect Diagram.](image2)

5. Analysis and Determination of Wear Image of Wheel Groove

5.1. Determination of Main Dimensions of Wheel Groove

At present, S-eye, H-Develop and other industrial camera driver software has been more popular(Sun 62), its online ranging function based on pixel size is also very mature, the image can be output after computer processing. The ranging interface is shown in Fig. 8.

![Figure 8. Ranging Interface.](image3)

By using the above-mentioned industrial camera driver software, the device can also be programmed with MATLAB GUI function. For the dimensions required for the feature extraction of the wheel groove, the following dimensions can be set as the key size, as shown in Fig. 9.

![Figure 9. Main dimensions of groove shape.](image4)

The computer will extract the above key dimensions and compare them with the detected dimensions.

5.2. Determination of the Wear Condition of groove

Firstly, according to the type and type of the wheel groove, the value of H1, W1, W2, W3 can be determined. Secondly, the H2 value of the same type of traction wheel groove is checked. If the H2 reduction exceeds 1/4 of the wire rope diameter of the traction wheel, the traction wheel groove can be
judged to be severely worn, the traction wheel should be removed for traction force test or be scrapped. When the H2 from any two groups detecting value reaches 1.5 mm, it is determined that the uneven wear of the wheel groove is serious, so the traction wheel should be repaired again. When the H2 value is less than 1 mm, it is determined that the traction wheel is a very serious wear, so the traction wheel should be replaced.

6. Conclusions
Based on the principle of machine vision recognition, a non-contact traction wheel groove wear detection device is designed. The detection field range of the designed detection device is 50–60 mm, and the detection accuracy is 0.01 mm. This design is characterized by the use of accurate and efficient machine vision. With the help of machine vision recognition technology, non-contact online measurement is realized. Which avoids the disadvantages of complex operation and low measurement accuracy of traditional measuring tools. Because it is not necessary to remove the traction wheel, the workload of the inspectors is greatly reduced. The device is of great significance to improve the safety of elevator operation, and reducing the cost of elevator detection, and improving the detection accuracy of components of elevator.

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