Public Traffic Type Escalator Driving Chain Broken: A Failure Analysis

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Abstract. The main drive chain of escalator is an important part of power transmission. In this paper, combined with an Escalator driving chain failure case, by taking a variety of analytical methods, such as visual inspection, chemical composition analysis, and microstructure, analysis on the cause of driving chain failure. According to analysis, we can conclude that the fracture of the drive chain is caused by the stress concentration effect of the bending stress of the transition plate, and the decarburization layer on the surface of the chain plate reaches 3.5% of the plate thickness, which accelerates the occurrence of fatigue cracking. So in the process of design and manufacture, the rationality of material, manufacturing and assembly process should be fully considered. Also in the use of the drive chain due to wear, impact, etc., to achieve the service life should be replaced in a timely manner.

Introduction

In April 2014, somewhere in the subway station transfer channel, a running upward escalator suddenly slipped rapid downward, causing most of the passengers standing on the step fell down, part of the injuries. The survey result goes as follows, drive chain rupture lead to Escalator reversal.

Figure 1. Accident scene.

The involved escalator is a public transport escalator, production date is October 2008, the rated speed is 0.65m/s, the step width is 1000mm, the lifting height is 5.8m, the tilt angle is 30 degrees. The involved escalator morning and evening rush hours are in heavy load, before the accident has been in normal condition, no accident precursor.
Analysis of Drive Chain Structure

At present, the most widely used driving chain type of escalator is the roller chain, the utility model is composed of an inner chain plate, an outer chain plate, a pin shaft, a sleeve and a roller.

Wherein, the inner chain plate and the sleeve, the outer chain plate and the pin shaft are all interference fit. Between the sleeve and pin shaft, roller and the sleeve are in clearance fit. When the number of links is even, the cotter pin or spring fixed card. When the link number is odd number, need a link transition, due to the transition link chain plate bending by the additional bending stress at work, so try to avoid using an odd number of link.
The standard of roller chain used in our country is GB/T 1243 - 2006 "short pitch precision roller chains, sleeve chains, attachments and sprockets", section 3. 6 "transition link": for heavy duty chain or under the high stress load chain should not use the transition link. The transition link will reduce the performance of the chain. With the transition link, the corresponding dynamic load strength should also be reduced accordingly.

**Failure Analysis of Escalator Drive Chain**

The involved escalator drive chain is double row roller, chain number: 20A-2, the pitch is 31.75mm, the maximum width is about 83.2mm (pin length). The driving chain plate adopted the transition link way, the fracture occurred in the middle part of the 4 transitional section of the chain plate, and there was no abnormal mechanical damage.

By scanning electron microscopy, the fracture is not scratch the starting edge area morphology under low power as shown in figure 6, the underside of the graph is the corner surface, parallel

![Figure 4. Roller link head.](image)

![Figure 5. Drive chain fracture morphology.](image)
extrusion formed in the stamping of mark can be seen; the upper part of the graph is a cross section, it can be seen that the edge of the extrusion belt, faintly visible small steps.

![Image](image_url)

Figure 6. Fracture initiation region of chain plate under low magnification Morphology.

Figure 7 shows that in the extended area, the parallel distribution of fatigue can be seen under quasi cleavage pattern, and there is a secondary crack along the fatigue pattern.

By metallographic analysis and hardness test results, the driven chain chain plate have different degrees of surface decarburization phenomenon, and by the surrounding surface of the decarburization layer can be inferred: decarburization occurs in the heat treatment, while the surface decarburization layer is deeper than the punching surface, indicating that the raw material has a decarburization phenomenon. Partial chain plate single - sided decarburization depth Is 3. 5% of the thickness. Surface decarburization reduces the surface fatigue strength of chain plate.

From Macroscopic and microscopic analysis of the fracture, the transition of driving chain plate fracture is fatigue fracture, and the fatigue fracture is related to stress concentration. At the same time, it is found that the cracking phenomenon can be inferred from the bending angle of the transition plate, there is obvious stress concentration effect on the bending angle of the transition plate.

Based on the above, it can be concluded that the fracture of the drive chain is caused by the stress concentration effect of the bending stress of the transition plate, and the decarburization layer on the surface of the chain plate reaches 3. 5% of the plate thickness, which accelerates the occurrence of fatigue cracking.

![Image](image_url)

Figure 7. Chain plate fracture extension fatigue striations.
Conclusion

The main drive chain of escalator is an important part of power transmission. In the process of design and manufacture, the rationality of material, manufacturing and assembly process should be fully considered. In the use of the drive chain due to wear, impact, etc., to achieve the service life should be replaced in a timely manner. At present, Shanghai has introduced a local standard DB31/T 746-2014 "escalator and automatic sidewalk main components sentenced to waste technical requirements", section 4. 6. 4 "drive chain" provides that the chain elongation exceeds the limit or the chain and sprocket cannot be normal meshing, should be sentenced to waste, this provides an important technical reference for escalator use and maintenance units.

References