Microstructure and wear property analysis of an elevator brake plunger

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Abstract. The microstructure and wear property analysis was performed on an elevator brake plunger. Based on the optical microscope and scanning electron microscope analysis, the macroscopic morphology, metallographic microstructure and wear property of the elevator brake plunger were investigated. The results showed that the material of elevator brake plunger is prone to adhesive wear.

1. Introduction

In case of emergency, the elevator brake can slow down the elevator until it stops. The microstructure and wear property of the elevator brake plunger are very important for the safety performance of elevator brake. Thus, the microstructure and wear property analysis of elevator brake plunger is very important to find out the failure cause of elevator brake.

Silva et al. [1] evaluated the relationship between microstructure and micro-abrasive wear performance of NiCrSiBC coatings. The results show that Cr₃B₁ changed abrasive particles interaction from grooving to rolling. Karakulak et al. [2] investigated the effect of Si addition on microstructure, hardness and wear resistance of as cast Mg-5Sn and Mg-10Sn alloys. The results show that the wear resistance of the binary alloys first increased with Si addition and then decreased. Wang et al. [3] investigated the microstructure and tribological property of the nitrided layer and as-cast high-entropy alloy. The results show that the main wear mechanism of the as-cast alloys in air and deionized water was adhesive wear, abrasive wear and oxidative wear. Moghaddam et al. [4] studied the microstructure and mechanical properties of the coatings. The results show that the hardest coating had the best wear resistance with the plowing and cutting wear mechanisms. Lakshmikanthan et al. [5] studied the influence of different weight fractions of dual size SiC particles on wear resistance and mechanical properties of A357 composites. Mirjavadi et al. [6] studied the effect of multi-pass friction stir processing on the microstructure, micro-hardness and wear properties of AA5083 sheets.

In this paper, the microstructure and wear property of an elevator brake plunger were investigated. The material properties and failure cause of the elevator brake plunger were analyzed.

2. Macroscopic morphology

The sample is a dismantled elevator brake, including one plunger and one spring rod. Because the sample has no nameplate and label, the sample brand and product serial number are indeterminate. The macroscopic morphology and sampling method of the elevator brake plunger are shown in Fig. 1. The surface of the elevator brake plunger is protected by oil layer, and no obvious wear and oxidation
phenomenon are observed. The paint at the end of the elevator brake plunger handle is basically off. The elevator brake plunger is about 90 mm in diameter and 90 mm in length. As shown in Fig. 1 (c), sampling is performed and then the microstructure, chemical composition, micro-hardness and friction and wear properties are analyzed.

3. Results and Discussions

3.1. Metallographic microstructure analysis
The sampling of the elevator brake plunger was analyzed by optical microscope. The results show that the microstructures of the elevator brake plunger are ferrite and dispersed flaky pearlite as shown in Fig. 2. The grain size of ferrite is relatively small, about 20-50 \( \mu m \).

![Figure 1. Macroscopic morphology of the elevator brake plunger.](image1.png)

![Figure 2. Metallographic microstructure of the elevator brake plunger.](image2.png)
3.2. SEM Micromorphology and Chemical composition analysis
The elevator brake plunger sample was also analyzed by scanning electron microscope (SEM). The low multiple SEM image of this sample is shown in Fig. 3(a). The high multiple SEM image of this sample is shown in Fig. 3(b). The distribution and structure of pearlite can be clearly observed. The result of X-ray energy spectrum analysis is shown in Fig. 3(c). It can be seen that the steel material contains less carbon and has no obvious other alloy elements, so it should be carbon steel. Compared with the pearlite content, it can be judged that the material may be 20 steel.

![SEM images](image1)

Figure 3. SEM morphology and chemical composition of the elevator brake plunger.

The micro-morphology and chemical composition of the elevator brake plunger side are shown in Fig. 4. Only a few scratches due to scratching can be observed on the side of the elevator brake plunger, and no obvious wear marks can be observed. At the same time, the oxygen content on the side of the elevator brake plunger is very small, indicating that there is no obvious oxidation.
3.3. Micro-hardness analysis

The Vickers hardness values of the elevator brake plunger are shown in Table 1. The average value of Vickers hardness is about 171.7. Because of its low hardness, it is presumed that the heat treatment state is annealed.

| Vickers hardness (HV0.1) | 1   | 2   | 3   | 4   | 5   | Average value |
|--------------------------|-----|-----|-----|-----|-----|---------------|
| Elevator brake plunger   | 162.8 | 171.5 | 178.2 | 176.9 | 169.0 | 171.7         |

3.4. Friction and wear properties analysis

The friction coefficient-time curve of the elevator brake plunger is shown in Fig. 5. The friction coefficient is about 0.25.
Fig. 6 shows the micro-morphology and chemical composition of the wear marks on the elevator brake plunger surface. In the process of friction and wear test, the material has a certain degree of adhesive wear, and the surface of the wear marks has a certain degree of oxidation.

4. Conclusion
The material of the elevator brake plunger is 20 steel and the heat treatment state is annealed. The material is prone to adhesive wear. There is no obvious wear or oxidation phenomenon during the use of the elevator brake plunger.

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