Failure analysis on magnetic ring of an elevator brake

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Abstract. A magnetic ring of elevator brake was analyzed in this paper. The macroscopic morphology and metallographic microstructure of the elevator brake magnetic ring were investigated based on the optical microscope and scanning electron microscope analysis. The chemical composition of magnetic ring was analyzed. The results showed that the abnormal wear was caused by the Zinc bearing metal.

1. Introduction

Elevator brake plays a very important role to the safe and secure operation of elevator. In an abnormal situation, the emergency start of elevator brake can reduce the severity of the accident. Thus, the reliability of the elevator brake parts is very important to prevent similar accidents from happening again.

Pal et al. [1] investigated a spring failed after 5 years of service which had expected life of 10 years. The results showed that the fracture surface under SEM showed striations confirming fatigue failure. Liu et al. [2] investigated a premature failure of the integral droppers in high speed railway catenary in China and provided a scheme to prolong the service life of integral droppers. Caballero et al. [3] studied the possible causes of the failure in-service of a section of a plastic modular belt. The FEA and injection molding simulations showed imperfections were due to poor design. Klakurková et al. [4] investigated the possible failure due to change of material and production technology. Material analysis and FEM study were carried out to decide if the material change was reason for the failure. Witek et al. [5] performed the failure analysis of the crankshaft of diesel engine. The results show that the failure of the crankshaft was caused by the high-cycle fatigue and the crack initiation was accelerated by improper chemical composition of the material and bad hardening process of pin area. Zhang et al. [6] established a finite element reduced order model and vibration frequency response measurement system to support dynamic response analysis of impeller. The results showed that the mistuning resulted in blade failure. More et al. [7] performed a failure analysis of coal bottom ash slurry pipelines in the thermal power plant. The results showed that the failure occurred due to the coal ash solid particle impact and deposited corrosion at the inner bottom surface of the pipeline.

In this paper, the reasons for the abnormal wear of elevator brake magnetic ring were investigated. The microstructure, chemical composition and micro-hardness of elevator brake magnetic ring were analyzed.
2. Macroscopic morphology
The macroscopic wear morphology of elevator brake magnetic ring is shown in Fig. 1. The mating zone between plunger and inner surface of magnetic ring had obvious wear phenomenon. It showed stripped distribution along the edge. The width was in the range of 17.5mm-18.0mm. The wear was uneven and mainly distributed on the both sides of the loosing hole.

Figure 1. Macroscopic morphology of elevator brake magnetic ring.

3. Results and Discussions

3.1. Metallographic microstructure analysis
On the cross-section of wear zone, there were some varying degrees of undulation. As shown in Fig. 2(a), the microstructures were ferrite and a little of pearlite. The high multiple OM image of wear zone is shown in Fig. 2(b). The surface microstructure showed rheological crack state after local extrusion. The black gray inclusion was embedded into the rheological layer. As shown in Fig. 2(c), the microstructures were ferrite, a little of pearlite and some intergranular free cementite. The black gray inclusion was analyzed by energy dispersive x-ray analysis. The results show that the Zn content is about 1.28% and O content is about 15.53%.

Figure 2. (a) Microstructure of wear zone; (b) High multiple OM image of wear zone; (c) Surface microstructure after local extrusion.
3.2. SEM analysis

The low multiple SEM (scanning electron microscope) image of wear zone is shown in Fig. 3(a). The wear marks distributed along the sliding friction direction were observed. There were rheology, folding and overlap phenomenon. The high multiple SEM image of wear zone is shown in Fig. 3(b). The metal rheology and crack phenomenon were observed on local surface of wear zone. The adhesion tensile fracture morphology is very obvious as shown in Fig. 3(c). The extraneous material was analyzed by energy dispersive x-ray analysis. The results showed that the Zn content was about 2.09%, O content was about 20.35% and Fe content was about 72.07%.

3.3. Chemical composition analysis

The chemical composition of escalator brake magnetic ring is shown in Table 1. The chemical composition of escalator brake magnetic ring is compared with DT4 referring to GB/T 6983-2008 < Soft magnetic iron >. The results show that the C, Si and Mn contents are beyond the standard while the Al and Cu contents are below standard.
Table 1 Chemical composition of elevator brake magnetic ring (wt.%).

| Element | C   | S    | Si  | Mn  | P   | Cr  | Ni  | Al  | Cu  |
|---------|-----|------|-----|-----|-----|-----|-----|-----|-----|
| Plunger | 0.092 | 0.008 | 0.20 | 0.48 | 0.011 | 0.049 | 0.037 | 0.014 | 0.085 |
| DT4     | ≤   | ≤    | ≤   | ≤   | ≤   | ≤   | ≤   | 0.20~ | ≤   |

DT4 ≤ 0.010, ≤ 0.010, ≤ 0.10, ≤ 0.25, ≤ 0.015, ≤ 0.10, ≤ 0.05, ≤ 0.80, ≤ 0.05.

3.4. Micro-hardness analysis

The Vickers hardness values of the center for elevator brake magnetic ring are shown in Table 2. The average Vickers hardness (HV1) value of magnetic ring is about 148.6.

Table 2 Vickers hardness of elevator brake magnetic ring.

| Points | 1   | 2   | 3   | 4   | 5   | Average value |
|--------|-----|-----|-----|-----|-----|---------------|
| Vickers hardness (HV1) | 150 | 147 | 150 | 148 | 148 | 148.6 |

4. Conclusion

The material of elevator brake magnetic ring didn’t meet the standard of DT4 referring to GB/T 6983-2008 < Soft magnetic iron >. The abnormal wear was caused by the Zinc bearing metal.

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