Analysis on an elevator brake magnetic sleeve

Facai Ren\textsuperscript{1}, Peng Qi\textsuperscript{2} and Xinghua Wu\textsuperscript{1}

\textsuperscript{1}Shanghai Institute of Special Equipment Inspection and Technical Research, Shanghai 200062, PR China
\textsuperscript{2}Yantai Productivity Promotion Center, Yantai 264003, PR China

Corresponding author e-mail: caifaren@163.com

Abstract. An elevator brake failed during use. Failure analysis was performed on magnetic sleeve of the elevator brake. The metallographic microstructure and SEM morphology of the elevator brake magnetic sleeve were investigated based on the optical microscope and scanning electron microscope analysis. The results showed that the entrance of foreign materials caused the extrusion wear to local area of the inner surface of the magnetic sleeve.

1. Introduction

In the process of using elevator, if the brake breaks down, it will lead to the accident of elevator and cause casualties. Brakes can reduce casualties in emergencies. The safety of brake is very important for the safe operation of elevator. The failure analysis of elevator brake magnetic sleeve is very important to prevent similar accidents from happening again.

Gong et al. \cite{Gong} studied an abnormal wear failure case of the wind turbine gearbox roller bearings caused mainly by service environment. Mussa et al. \cite{Mussa} investigated the rock drill rods, which were manufactured from 22NiCrMo12-5F steel, failed during field operations. The results show that sliding and abrasive wear damage, severe plastic deformation and pitting corrosion caused the rock drill rods failure. Fei et al. \cite{Fei} studied a localized abnormal wear failure case of methyl acrylic acid extraction column inner wall and proposed pertinent countermeasures to prevent the recurrence of similar incidents. Fonte et al. \cite{Fonte} studied the root cause of a catastrophic failure of a diesel motor crankshaft. The results show that the fatigue caused the crankpin and the main bearing cap failure. María et al. \cite{Maria} studied the failure reason of the rod-end bearing from an actuating cylinder used to open and close the left main landing gear inboard door of an aircraft. The results show that the failure mechanism is solid–metal induced embrittlement. Vicente et al. \cite{Vicente} investigated the root causes of failure of the coupled shaft using both experimental methods and theoretical calculations. The results show that the radial misalignment plays an important role on the failure of the coupled shaft. Zhao et al. \cite{Zhao} investigated the root cause and failure mode of drive shaft failure in a vehicle based on the morphology, chemical composition and metallographic analysis. The results show that the fatigue was the dominant mechanism of drive shaft failure.

In this paper, the magnetic sleeve of an elevator brake was investigated based on the metallographic microstructure, SEM and micro-hardness analysis.

2. Macroscopic morphology

The wear morphology of the magnetic ring and the magnetic sleeve on both sides of an elevator brake is shown in Fig. 1. As shown in Fig. 1 (E1), serious wear and tear along the circumference can be seen.
in the inner surface of the installation hole of the loose bar, showing plough groove and pull injury. The wear and tear of the magnetic ring, but there is no tear in the inner and outer areas of the corresponding magnetic sleeve, which indicates that abnormal wear develops from the ring (central area) to the sleeve (outer side), as shown in Fig. 1 (E2). The distribution of wear area on the inner surface of the magnetic sleeve is basically consistent with that of the magnetic ring, as shown in Fig. 1 (E3). However, there are some inconsistencies at the end of the wear zone.

Figure 1. The wear morphology of the magnetic ring and the magnetic sleeve of an elevator brake.

One of the magnetic sleeves and its wear morphology is shown in Fig. 2. The outer diameter of the magnetic sleeve is about 102 mm and the width is about 5 mm. The inner diameter of the magnetic sleeve is about 95.1 mm. The inner surfaces of the two magnetic sleeves and plungers are subjected to non-uniform wear, and the wear area basically corresponds to the inner surface of the magnetic ring. The wear area presents plough-groove shape with different depths. However, there is no obvious wear and tear in some areas, and circular machining traces are still visible.

Figure 2. Magnetic sleeve and wear morphology.
3. Results and Discussions

3.1. Metallographic microstructure analysis
The magnetic sleeve of an elevator brake was analyzed by optical microscope. On the cross section of the local wear zone, the surface wavy depression can be seen as shown in Fig. 3(a). At high magnification, the concave area is accompanied by extrusion rheology and defect morphology as shown in Fig. 3(b) and Fig. 3(c). It can be seen that the microstructure consists of ferrite, pearlite and grey inclusions with voids. The matrix structure is ferrite and pearlite, as shown in Fig. 3(d).

![Figure 3](image)

Figure 3. Metallographic microstructure of elevator brake magnetic sleeve.

3.2. SEM analysis
The morphology of the local wear area at low magnification is shown in Fig. 4(a). It can be seen that there are wear grooves with different width and depth along the direction of friction and sliding, and some of them run through the magnetic sleeve. At high magnification, the morphology of adhesive pull and rheological crack can be seen in the wear area, as shown in Fig. 4(b) and Fig. 4(c), respectively. In the non-wear zone, the original machined trace remains, as shown in Fig. 4(d).
Figure 4. SEM morphology of elevator brake magnetic sleeve.

3.3. Micro-hardness analysis
The Vickers hardness (HV) values of the center for elevator brake magnetic sleeve are shown in Table 1. The average value of Vickers hardness (HV) is about 157.7.

| Points | 1      | 2      | 3      | 4      | 5      | Average value |
|--------|--------|--------|--------|--------|--------|---------------|
|        | 157.5  | 158.6  | 156.8  | 158.3  | 157.4  | 157.7         |

4. Conclusion
The local area of the inner surface of the magnetic sleeve is subjected to extrusion wear related to the entrance of foreign materials.

References
[1] Y. Gong, J.L. Fei, J. Tang, Z.G. Yang, Y.M. Han, X. Li, Failure analysis on abnormal wear of roller bearings in gearbox for wind turbine, Eng. Fail. Anal. 82 (2017) 26-38.
[2] A. Mussa, P. Krakhmalev, J. Bergström, Failure analyses and wear mechanisms of rock drill rods, a case study, Eng. Fail. Anal. 102 (2019) 69-78.
[3] J.L. Fei, X.L. Yang, S.H. Wang, Y. Gong, J. Wang, X. Tao, Z.G. Yang, Failure analysis and countermeasures for localized abnormal wear of MAA extraction column, Eng. Fail. Anal. 100 (2019) 166-179.
[4] M. Fonte, M. Freitas, L. Reis, Failure analysis and countermeasures for localized abnormal wear of MAA extraction column, Eng. Fail. Anal. 102 (2019) 1-6.
[5] G.M. Maria, F.J.G. B. Villanueva, M.P.V. González, P.M. Ana, Failure analysis of the rod-end bearing of an actuating cylinder, Eng. Fail. Anal. 104 (2019) 292-299.
[6] C.M.S. Vicente, M. Sardinha, L. Reis, Failure analysis of a coupled shaft from a shredder, Eng. Fail. Anal. 103 (2019) 384-391.
[7] L.H. Zhao, Q.K. Xing, J.Y. Wang, S.L. Li, S.L. Zheng, Failure and root cause analysis of vehicle drive shaft, Eng. Fail. Anal. 99 (2019) 225-234.