IOP Conf. Series: Materials Science and Engineering **423** (2018) 012053 doi:10.1088/1757-899X/423/1/012053

Fracture Failure Analysis on Main Wheel Hole of Escalator Step

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Abstract. The escalator steps used in a building fractured during applications. The cause for escalator step fracture has been investigated systemically. The supporting rod main wheel hole of escalator step was studied by means of chemical composition analysis, scanning electron microscope and optical microscope.The results indicate that there are some porosity defects in the support rod of escalator step.The fracture mode of main wheel hole is overload brittle fracture.

1. Introduction

Escalators are also called moving staircase and widely used for carrying passengers up and down in public places such as subway, supermarkets and shopping malls. With the increasing use of escalators, the casualties and property losses caused by escalator are increasing [1]. Thus, how to guarantee safety of escalator is a problem to be solved imperatively [2-5].

During applications of the escalator in a building, six steps were arched upward and damaged due to the collision and two persons were injured. In this paper, the cause for supporting rod main wheel hole fracture of escalator step was analyzed by means of macro, scanning electron microscope and optical microscope.

2. Accident Scene and Analysis Method

The accident scene of escalator is shown in Fig. 1. It can be seen that the main hole of escalator step fractured. Some parts of the main wheel hole scattered on the fixed frame. The supporting rod with main wheel hole of escalator step is shown in Fig. 2. It can be seen that both supporting rod A and supporting rod B have no obviously plastic deformation.

The fracture of supporting rod main wheel hole of escalator step was analyzed by the scanning electron microscope referring to JB/T 6842-1993<Test methods of scanning electron microscope>. The microstructure of the supporting rod main wheel hole of escalator step was analyzed after etching referring to GB/T 13298-1991 <Inspection methods of microstructure for metals>.

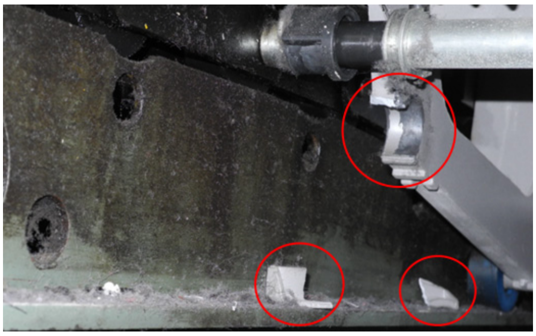

Figure 1. The accident scene.

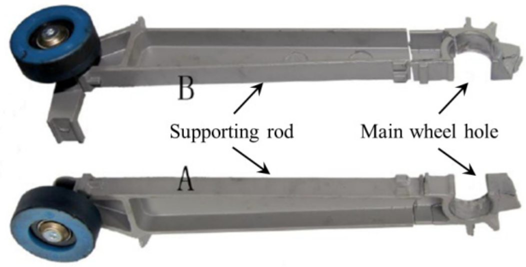

Figure 2. The supporting rod of escalator step.

3. Results and Discussions

3.1 Chemical Composition Analysis of escalator step

The chemical composition of escalator step is shown in Table 1. The chemical composition of escalator step matches to the technical requirements of YL102 referring to GB/T 15115-2009 <Die casting aluminum alloys>.

Table 1. Chemical composition of escalator step (wt.%).

Element	Si	Cu	Mn	Mg	Fe	Zn	Al
Escalator step	11.88	0.025	0.20	0.019	0.85	0.005	bal.
YL102	10.0~13.0	≤1.0	≤0.35	≤0.1	≤1.0	≤0.4	bal.

3.2 Macroscopic Fractography of Fractured Main Wheel Hole

Macro morphology of both main wheel holes of escalator step is shown in Fig. 3. It can be seen that the main wheel holes of supporting rod A and supporting rod B have fractured into three parts. The shape of fracture part of two supporting rod is almost the same. It can be inferred that the two main wheel holes have the same fracture mechanism. The fracture morphology of the two main wheel holes is basically similar. During the occurrence of crack, there is plastic deformation phenomenon. The crack lengths of main wheel hole A and B are 4.9mm and 6.5mm, respectively.

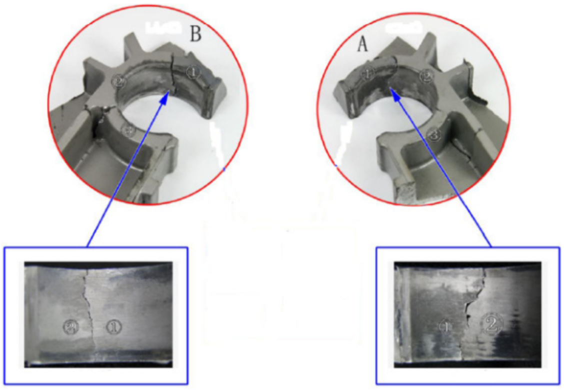

Figure 3. Macro morphology of the main wheel hole.

Macroscopic fractography between the part ① and part ② of main wheel hole is shown in Fig. 4. Fracture started from this crack based on the analysis of fracture surface. There is no obvious plastic deformation on the fracture. The fracture surface is silver gray and rough. There are radiation stripes on the fracture surface from the inside to the outside.

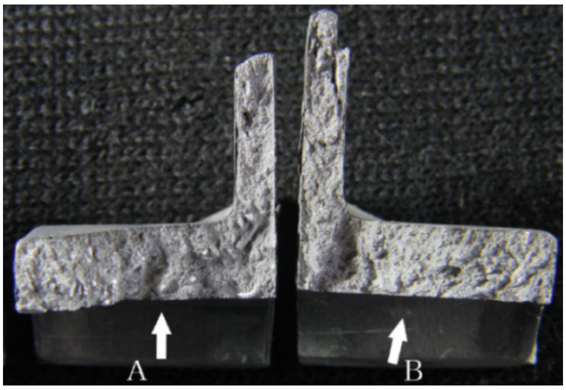

Figure 4. Macroscopic fractography of the main wheel hole.

3.3 SEM Analysis of Fracture

The low multiple SEM image of zone ① in part A is shown in Fig. 5. It can be seen that there are top-down stripes and tearing small flats. The fracture surface fluctuation is large.

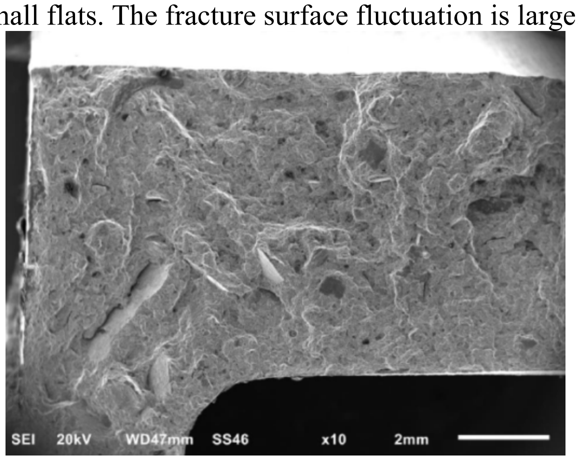

Figure 5. Macroscopic fractography of the main wheel hole.

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The fracture initiation region SEM image of zone ① in part A is shown in Fig. 6. It can be seen that the fracture surface shows quasi cleavage pattern and there are some scratches on the edge. There is no flat zone related to the fatigue initiation.

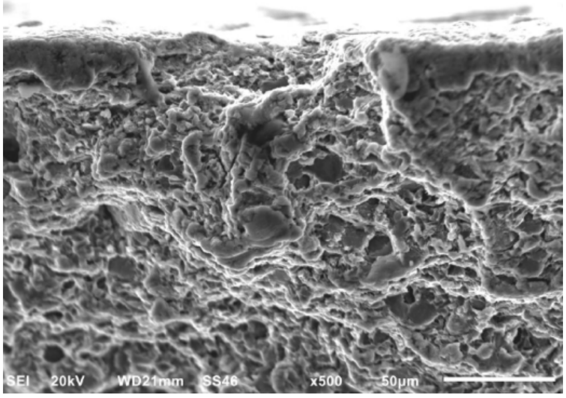

Figure 6. Fracture initiation region SEM image of zone ①in part A.

The fracture propagation region SEM image of zone ① in part A is shown in Fig. 7. It can be seen that there are tearing ridge and small pit defects on the quasi cleavage pattern. Based on further analysis, the small pit defect belongs to micro porosity. There are tearing secondary crack in local area.

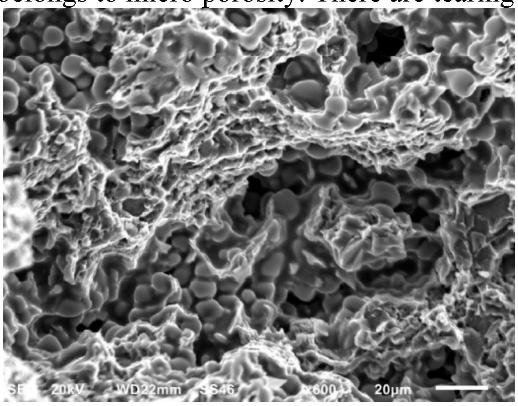

Figure 7. Fracture propagation region SEM image of zone ① in part A.

3.4 Fracture Analysis of Microstructure

The optical microstructure of the crack region is shown in Fig. 8. It can be seen that the crack width is not alike, which is related to the original porosity defect. The matrixes are α(Al) phase and eutectic silicon phase.

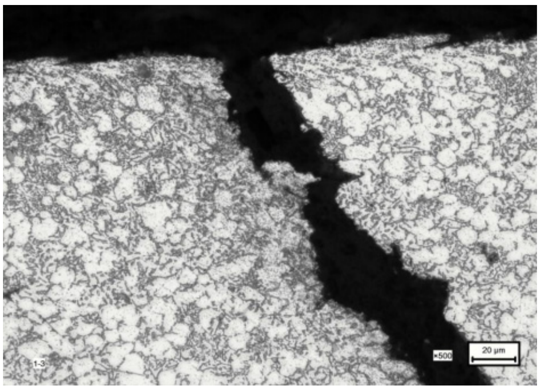

Figure 8. Optical microstructure of the crack region.

The distribution morphology of crack close to the edge is shown in Fig. 9. It can be seen that the crack length is about 0.08mm. The crack opening is relatively bigger, which indicates that it is related to tensile fracture.

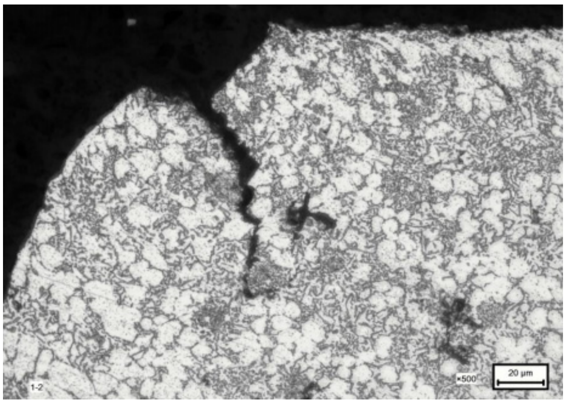

Figure 9. Crack distribution morphology.

4. Conclusion

The supporting rods of escalator step have some porosity defects, which can reduce the strength of main wheel hole and influence the path of fracture process. The fracture mode of escalator step investigated in this study is overload brittle fracture.

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