Analysis and Research on Current-carrying Friction and Wear of High-speed Train Pantograph Slide and Contact Wire Based on Computer Simulation Analysis

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Abstract. High speed train has many advantages, such as large capacity, fast speed, low cost, small energy consumption, economic and environmental protection, safety and comfort, which has become an important part of high-speed railway in China. Therefore, pantograph catenary system will become an important part of high-speed train. However, due to the vibration of the high-speed train or the irregularity of the contact wire, the pantograph slide plate and the contact wire will produce an arc, which will lead to friction and wear. Therefore, under the complex environment, the pantograph slide plate and contact wire will form a mechanical and electrical wear coupling, which will make the current carrying friction and wear between the pantograph slide plate and contact wire more complex. Therefore, high-speed trains will suffer more problems, which will further restrict the speed-up of locomotives. Therefore, this paper first uses computer simulation technology to analyze the working relationship between pantograph slide plate and catenary of electric locomotive. Then, the friction and wear characteristics of pantograph slide plate and contact wire are studied by experiment.

Keywords: High Speed Train, Pantograph Slide Plate, Contact Wire, Current Carrying Friction and Wear, Computer Simulation Analysis

1. Introduction

With the rapid development of China's high-speed railway, the speed of China's high-speed railway is also increasing. High speed train has become an important part of China's electrified railway, which has been paid attention by all countries in the world. At present, the operation speed of high-speed trains in China has reached 350 km/h, and the maximum test speed has reached 486.1 km/h, which proves the capability of high-speed trains in China¹. However, the research on the relationship between pantograph and catenary of high-speed trains in China is relatively weak, which seriously restricts the reliability evaluation of high-speed trains in China. Pantograph catenary system is the most critical component of high-speed train, which directly determines the safe operation of the train. However, due to the vibration of the high-speed train or the irregularity of the contact wire, the pantograph slide plate and the contact wire will produce an arc, and
the temperature will reach 3000-5000 K, which will cause the material erosion. Therefore, friction and wear will occur on the surface of the material.

2. Pantograph slide plate and contact wire of high-speed train

2.1. High speed train and catenary

The high-speed train is driven by electric energy, which requires the catenary to obtain electric energy. Through the catenary, the high-speed train drives the wheels of the locomotive by the electric motor. We can arrange contact wires in zigzag shape, which can effectively avoid concentrated abrasion of contact wires on pantograph slide plate. Therefore, we can improve the service life of skateboard. The current can be divided into DC and AC, which can be divided into three types of high-speed trains, such as direct all-time, AC all-time and AC all-time. The schematic diagram of high-speed train and catenary is shown in figure 1[2].

![Figure 1. The schematic diagram of high-speed train and catenary.](image)

1 is the foundation of catenary,
2 is the pillar of catenary,
3 is the supporting device,
4 and 10 are the insulator,
5 is the bearing cable,
6 is the hanging string,
7 is the elastic hanging string,
8 is the contact wire,
9 is the positioning frame,
11 is the positioning tube,
12 is the pantograph.

2.2. Pantograph slide plate

Pantograph slide plate is an important collector for high-speed train to obtain power source, which is installed at the top of pantograph and contacts with catenary wire, as shown in Figure 2. The slide plate receives current from the catenary wire, which will maintain the normal operation of high-speed train. Good pantograph slide plate needs to meet many characteristics, such as high mechanical strength, wear resistance, high lubrication, small resistivity, good heat resistance, arc resistance, lightweight, standardization, weather resistance, etc. Pantograph slide plate is a kind of sliding friction collector material, which is mainly divided into metal base slide plate and carbon series slide plate[3].

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**Figure 1.** The schematic diagram of high-speed train and catenary.
2.3. Interaction model of pantograph and contact wire

The interaction between contact wire and pantograph is an important factor to provide power quality and reliability, which plays an important role in power transmission. The two are two independent elastic systems, which will make electrical and mechanical contact to power the traction vehicle. Therefore, we must guarantee the low abrasion of contact wire and sliding plate, which will reach the condition of long life and low maintenance. The interaction model of pantograph and contact wire is shown in Figure 3.

3. Analysis on current carrying friction and wear

This test is carried out on the high-speed pantograph catenary relationship test bench equipped in the high-speed pantograph catenary relationship laboratory\cite{4}.

3.1. Test materials

This paper refers to TB / T 2809 copper and copper alloy contact wire for electrified railway and ocs3. Three types of contact wires, CTS150, CTMH150 and CTCZ150, were selected for the test. In this paper, two kinds of pantograph are selected to carry out current friction test, including CX-NG of metal impregnated carbon slide plate and dsa380 of pure carbon slide plate.

3.2. Current carrying friction and wear performance of metal impregnated carbon sliding plate

In this paper, the quality of sliding plate, the height of contact line and the cross-sectional area of contact line are tested respectively, and then the current carrying friction and wear performance of three contact lines are analyzed respectively. Finally, we get the relationship curve of the three lines, as shown in Figure
4. Figure 5 and Figure 6. Therefore, we can get the current carrying friction and wear performance relationship of the metal impregnated carbon skateboard[5].

Figure 4. Mass abrasion ratio curve of metal impregnated carbon sliding plate

Figure 5. Height abrasion ratio curve of metal impregnated carbon sliding plate

Figure 6. Abrasion ratio of contact wire section.

Figure 7. Mass abrasion ratio curve of pure carbon sliding plate.

3.3. Current carrying friction and wear performance of pure carbon sliding plate

In this paper, the quality of sliding plate, the height of contact line and the cross-sectional area of contact line are tested respectively, and then the current carrying friction and wear performance of three contact lines are analyzed respectively. Finally, we get the relationship curve of the three lines, as shown in Figure 7, Figure 8 and Figure 9. Therefore, we can get the current carrying friction and wear performance relationship of pure carbon sliding plate[6].
4. Conclusion

Through the use of computer simulation analysis, we can draw the following conclusions: in the process of current carrying friction between metal impregnated carbon slide plate and contact line, the wear ratio of different friction pair materials is quite different, while that of pure carbon slide plate is relatively small.

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