Analyzing the Causes of Tread Damage in Metro Vehicles

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ABSTRACT

This paper makes a detailed investigation, analysis and research on the problems of tread abnormal wearing in the process of metro vehicles running. This paper analyzes the basic physical performance of brake shoes, according to the friction and wear test, measuring the material granularity of brake shoes using Tyler standard screen and so on, and focuses on how to design brake shoes according to different operating conditions, to evaluate the thermal load of wheels under service braking condition during vehicle operation, to solve the problem of vehicle tread damage.

KEYWORDS

Thermal load of wheels; Friction and wear test; Metro vehicles; Tread damage

INTRODUCTION

In the urban road traffic system, subway transportation has occupied the absolute dominant position of urban traffic. According to statistics, by December 2018, Beijing had more than 22 subway lines in operation, covering 11 municipal districts in Beijing, with a mileage of more than 600 kilometers and more than 390 stations in operation, ranking the second in China. By 2020, Beijing's subway will have a network of 30 rail lines, with a total length of 1,177 kilometers.

Behind the rapid development of subway, the safety and reliability of operation has become the focus of concern. This paper mainly discusses the wheel damage problem commonly appeared in subway cars, expounds its causes, investigation and analysis, from various aspects and levels.

ANALYSIS OF THE SURVEY

In some subway vehicles, as shown in Fig. 1, small pits appear on the wheel tread, which is point-like damage, and the wheels on both sides of the same axle are symmetrically distributed.
In some other subway vehicles, after a period of operation, the wheel tread damage as shown in Fig. 2 is found, with serious peeling and groove wear.

In some subway vehicles, after a period of operation, the wheel tread damage as shown in Fig. 3 appears, with serious peeling phenomenon.

According to previous operating experience, the Fig. 1 is the typical wheel sliding wheel sliding on the steel rail abrasions. In general, the typical phenomenon is this point wheel abrasion occurs on two wheels with the same axial symmetry. Through theoretical analysis and experimental verification, this phenomenon can be significantly solved by improving the vehicle sliding mechanism, which is
common in railway vehicles and has been an effective solution. Therefore, this paper mainly aims at the wheel damage in Fig. 2 and Fig. 3.

ANALYZING THE CAUSES

The cause of grooved wheel damage and tread peeling damage may come from one of track, wheel and brake shoe. Generally, there are four possible causes of wheel damage in the running process of vehicles.

- Brake shoe cause
- Wheel cause
- Braking Control cause
- Orbital cause

Brake shoe causing

The quality problem of brake shoe itself can be found in the early stage of vehicle operation. The brake shoe is sampled and tested to determine whether there is a factor of the brake shoe itself.

Physical and chemical performance analysis of brake shoes is one of the most effective ways. Table 1 is the physical and chemical performance report of brake shoes used in the operation of one subway train.

<table>
<thead>
<tr>
<th>Item</th>
<th>Water absorption rate</th>
<th>compression modulus (Mpa)</th>
<th>bonding strength (Mpa)</th>
<th>Density (g/cm³)</th>
<th>hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>0.9</td>
<td>983</td>
<td>1.1</td>
<td>1.8</td>
<td>65.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Item</th>
<th>Oil absorption rate</th>
<th>Impact strength (KJ/m²)</th>
<th>compression Strength (Mpa)</th>
<th>bending strength (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>1.1</td>
<td>6</td>
<td>65</td>
<td>13.6</td>
</tr>
</tbody>
</table>

It is an important method to analyze the friction and wear performance of brake shoe. Fig. 4 shows the wear performance curve of subway brake shoe.
If the friction coefficient of the brake shoe is higher, or the hardness is higher, or the strength is higher, the wear of the brake shoe itself will be lower, and the durability of the brake shoe itself will increase, but the problem is that the friction pair of the brake shoe -- the wheel wear will increase. If the friction coefficient of brake shoe is too small, or the hardness is too small, or the strength is too small, its own wear will be too large, the problem is that the brake shoe consumption is too fast, not conducive to cost saving and environmental protection. Therefore, in addition to analyzing, testing and investigating the brake shoe, the friction coefficient, modulus, hardness, strength and other indicators should be controlled within a reasonable range, so as to maintain the reasonable wear range of brake shoe and wheel.

If the friction coefficient, hardness and other parameters of the brake shoe are basically normal performance, in order to find the difference of the friction performance, the brake shoe should be measured on granularity. For material granularity measurement, Tyler standard screen is used to quantify the size of material granularity which determines the size of the silvers during the process of brake shoe. The size of the silvers well be bigger when the size of material granularity is bigger; the physical performance of big material granularity is easier to change when it cohere to the surface of brake shoe. Sometimes, it will be metal frit and sometimes, it will be rubber frit.

In order to get the mesh size of brake shoe accurately, the general method is to weighted average the measured mesh size. The final data obtained, the high granularity of brake shoe, often to the wheel tread damage. The reason is, big size metal frit is formed during the process of brake shoe when big size silvers cohere to the surface of brake shoe and brake shoe disc because of damp. The damage is great because big change is happened in physical performance of this kind of metal frit for which hardness is always bigger than brake shoe and wheel tread, and it always bind with surrounding silvers to be bigger.

**Wheel cause**

Wheel material, hardness and other inherent characteristics of the inspection and
verification. Through the sampling analysis of subway wheels, the test results are compared. The analysis of the wheel is relatively simple, here do not elaborate. However, the impact of the wheel itself on the problem cannot be ignored.

**Braking control cause**

In the running of vehicle operation, the frequent use of air brake makes the brake shoe temperature higher, although it does not exceed the allowable temperature limit, but the brake shoe in high temperature frequent using, resulting in carbon hardening will cause considerable damage to the wheel.

The principle and control mode of signal system have great influence on the frequency and size of vehicle braking.

Measurement of braking force and parameters can be seen in Table 2 and Fig.5.

<table>
<thead>
<tr>
<th>Table 2. Measurement data line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement data</td>
</tr>
<tr>
<td>Train speed</td>
</tr>
<tr>
<td>Brake cylinder pressure</td>
</tr>
<tr>
<td>Brake status signal</td>
</tr>
<tr>
<td>Brake grade signal</td>
</tr>
<tr>
<td>Electrical braking signal</td>
</tr>
<tr>
<td>Instantaneous reduction rate</td>
</tr>
</tbody>
</table>

![Figure 5 Braking curve](https://via.placeholder.com/150)

The operation data of train braking system during the whole day should be recorded not only during the peak period, but also during the low peak period. Comprehensive analysis of operating conditions, the calculation of train braking
force on the wheel thermal load. If the performance of electric braking is limited or the situation is poor, the friction braking will be relatively elevated, and the vehicle will run under a high thermal load for a long time, which will also cause abnormal wheel wear.

**Steel rail cause**

At present, there are two kinds of rails widely used in China's railway and urban rail transit, mainly middle manganese rail (U71Mn) and vanadium micro-alloy rail (U75V).

According to "technical conditions for ordering steel rails of 43kg/m ~ 75kg/m" (TB/ t2344-2012), the mechanical properties of U75V and U71Mn rail are shown in Table 3.

<table>
<thead>
<tr>
<th>Item</th>
<th>Rail material</th>
<th>production process</th>
<th>$\sigma_b$ (Mpa)</th>
<th>$\sigma_s$ (Mpa)</th>
<th>$\delta_s$ (%)</th>
<th>HB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>U71Mn</td>
<td>Hot rolled</td>
<td>$\geq 882$</td>
<td>$\geq 490$</td>
<td>$\geq 8$</td>
<td>270</td>
</tr>
<tr>
<td></td>
<td>U75V</td>
<td>Hot rolled</td>
<td>$\geq 980$</td>
<td>$\geq 610$</td>
<td>$\geq 8$</td>
<td>300</td>
</tr>
</tbody>
</table>

Rails of two materials have the following characteristics.

1. Vanadium containing micro alloy rail (U75V) has better hardness and wear resistance due to its high silicon content and the addition of a small amount of vanadium. The railway operation practice shows that the wear resistance of vanadium micro-alloy rail (U75V) is more than 60% higher than that of medium manganese rail (U71Mn) on the curve of small radius, and the service life is 1.5 ~ 2 times that of medium manganese rail (U71Mn).

2. The tensile strength, yield strength and tensile properties of vanadium micro alloy rail (U75V) are higher than those of medium manganese rail (U71Mn).

To sum up, although the price of vanadium micro-alloy rail (U75V) is higher than medium-manganese rail, due to its long service life and good wear resistance, the on-site maintenance and maintenance workload can be reduced and operating costs can be reduced.

Rail maintenance and the use of its own performance is equally important. In general, routine maintenance requires the following.

1. To carry out line work, through a variety of ways to see, listen to, find the basic situation of the line. Focus on the fork, bend and other wheels have a greater impact on the section, and track noise is relatively large section.
(2) The opening of most subway vehicles in China is on the new track. Before the formal operation of the vehicles, special track cars are usually used to polish the new track. If the vehicle is running on an unpolished track, the track is rubbed and there is a constant process of fine particles being separated from the track and getting stuck on the moving wheels. In the absence of any external force, the flecks repeat the fall-fall-fall process. In the process, the wheel will have numerous fine pits. When the brake is applied, the shoe attaches to the wheel, trapping the fine particles between the wheel and the shoe. Because the chips are harder than the wheels and shoe, the wheels and shoe are worn at the same time. As the running time increases, the wear increases further, resulting in the situation in Fig. 2.

Once it occurs, trench wear cannot disappear and continues to progress over time. After some wheels are rotated, the degree of abnormal wear is reduced, but the problem of abnormal wear has not been completely solved. Only after many years of operation and wheel repair, the track condition gradually improved, the fault can slowly disappear.

CONCLUSION

The reason of wheel wear may be the result of the comprehensive effect of various factors. However, it is still the unremitting pursuit to improve braking performance to adjust various factors and make the train achieve the optimal matching in all aspects.

REFERENCES


