Brake Lining Can be Applied to Super High Speed Vehicle

Satoru Nakano¹ᵃ, Takashi Maejima²ᵇ
¹FINE SINTER, CO. LTD., 5-1, Kitsunezuka, Kurisuno, Yamashina-ku, Kyoto, JAPAN
²ᵃs-nakano@fine-sinter.com, bmaejima@fine-sinter.com

Abstract

A new material was developed to achieve improvement of heat durability, improvement of wear resistance, stability of friction coefficient and reduction in aggression to counterpart, because it is difficult to maintain braking properties by using currently available materials in the train wagons used for high-speed transportation. As a result, the new material showed a stable wear resistance even in the speed range of 350km/h, where improvement was also confirmed in reduction of aggression to counterpart material by more than approximately 10%. This development was adopted for the brake lining in the Taiwan High Speed Rail project.

Keywords: friction coefficient, heat durability, aggression to counterpart

1. Introduction

Recently a trend to accelerate train speed has become more evident than ever with the background of global growth of high speed railroad transportation, where operation speed as high as 350km/h is planned for the future versus 300km/h, which is the current maximum operation speed (in Germany, France, Taiwan and Japan [JR West]). Along with the speed increase trend in trains, the brake lining size has been minimized to reduce train weight. However, the stress applied to the brake lining has increased because the energy absorbed by the brake system is proportional to the square of the speed (E=1/2 • mv²). Giving consideration to such an increase of severity in operation conditions, it is difficult to use currently available materials repeatedly because they tend to melt after some cyclic use.

In this project, a brake lining was developed that could sufficiently endure the operation conditions required to achieve 350km/h as a target speed.

2. Experimental and Results

1) Main emphasis of the development
(1) Improvement of heat durability
During the braking under high speed, the surface immediately under the sliding face is exposed to a temperature as high as 800-1000°C, resulting in melting of matrix in the currently available lining materials. Accordingly, heat resistance of the materials has been widely enhanced by changing the material from a Cu-Sn-based material to a Cu-Sn-Ni-Cr-Fe-based material.

(2) Stability of wear performance
The conventional ceramic content has been approximately 10% in general, but it was significantly increased to 8 to 15% and the result has been an improvement in abrasion resistance and stabilization of the friction coefficient. There also was an improvement in heat resistance to high-range temperatures. Ceramics with low Moh’s hardness was added, taking into consideration the aggression property to counterpart material.

(3) Improvement of lubrication property
Graphite content as a lubrication content was added as much as possible to improve lubrication property. Besides, because the graphite has an effect to reduce heat stress on a brake lining (by reducing heat conductivity), heat durability of the brake lining was improved, too.

(4) Optimization of manufacturing conditions
Because decrease in material strength was expected in the conventional manufacturing conditions due to the change in material matrices and significant increase of graphite content, optimization of sintering method was conducted (temperature / pressure conditions) to improve material strength.

Table 1. Mixing composition (wt%)

<table>
<thead>
<tr>
<th></th>
<th>Cu</th>
<th>Fe(Ni-5 Cr)</th>
<th>ZrO₂</th>
<th>MgO</th>
<th>Al₂O₃</th>
<th>SnO₂</th>
<th>Mo</th>
<th>Mn</th>
<th>Others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>50-70</td>
<td>3-6</td>
<td>3-8</td>
<td>8-13</td>
<td>3-9</td>
<td>4-10</td>
<td>Remaining</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New material</td>
<td>30-70</td>
<td>2-20</td>
<td>8-15</td>
<td>10-15</td>
<td>1-5</td>
<td>2-7</td>
<td>Remaining</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2) Experiment result
(1) Heat resistance
A stationary brake test was conducted under conditions equivalent to actual train operation to measure the peak temperature and abrasion level of the lining. The result of the braking test from 350km/h showed that the temperature and abrasion level of the developed material were equivalent to those of the conventional material (tested with...
braking from 320km/h). As the developed material has greater heat resistance, the abrasion level declined because of the reduction in the surface layer’s loss caused by melting.

![Fig. 1 Abrasion-Graph of temperature](image)

(2) Friction coefficient

Fixed position braking test was conducted using the conditions equivalent to actual train operation to measure the friction coefficient. The new material showed no decrease in friction coefficient even in the high speed range of above 250km/h in comparison with the conventional materials. The new material showed stable braking property from 350km/h to the complete stop by maintaining the friction coefficient higher than 0.25.

![Fig. 2 Graph of instant friction coefficient](image)

(3) Aggressiveness to counterpart material

Aggressiveness to counterpart material was measured by continuous friction test using a pin-on-the disk friction tester. The aggressiveness of the new development to counterpart material indicated an improvement by 10% versus the conventional material.

![Fig. 3 Surface roughness of the counterpart material after friction test](image)

3. Summary

While conventional brake lining has its limit in the range of operation speed of 320km/h, the new material showed stable friction characteristics up to 350km/h. Further, the new material showed an improvement by more than approximately 10% in the aggression to counterpart material in comparison with the conventional materials. Consequently, the new material was adopted as the brake lining for the Taiwan High Speed Rail trains. Further expansion of the domestic and international markets is expected for the new material in future.

![Fig. 2 Product appearance](image)