Copper Free Brake Pads with Stable Friction Coefficient

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1 Abstract

Highly controlled brake systems such as "regenerative brakes" and "automatic brakes" have become common for automobiles over the past few years. It is essential for the new brake systems to maintain stable brake force, so the stability of friction coefficient generated by brake pads is becoming increasingly important. On the other hand, requirements for eco-friendliness of materials contained in brake pads are getting tighter, and regulations to eliminate copper will start in North America from 2021[1, 2].

To cope with this situation, we have developed "copper free brake pads with stable friction coefficient" by substitution of alternative materials to perform copper functions, such as thermal conductivity and lubricating property, and improvement to reduce the component change of the friction surface before and after braking. As an additional result, we have achieved brake noise reduction.

2 Characteristics of the Product

- The product contains no copper (conforms to the copper regulation to be enacted in North America from 2025).
- The friction coefficient remains stable after high-temperature braking and when left in high-humidity environments.
- The brake rarely squeaks or emits other low frequency noises.

3 Background of the Development

Copper has a melting point higher than 1000°C and high ductility. As a result, it forms a film on the friction interface (**Figure 1**), causing an increase in the thermal conductivity and heat resistance of the brake pads (**Figure 2**). This is why copper is an essential material for brake pads. However, the copper contained in the friction powder discharged by braking has the risk of contaminating water.[3, 4] For this reason, a regulation was established in North America, limiting the copper content in brake pads to 5 wt% or less by 2021 and to 0.5 wt% or less by 2025.

Furthermore, as a result of the spread of high-performance brake systems, the friction coefficient of brake pads is now required to be even more stable than before. In addition, in EVs and HEVs where the silence of the drive system has dramatically improved, there are now higher standards regarding the reduction of squeaking or low frequency noises emitted by brakes. Because the breaks squeak or emit low frequency noises when the friction coefficient increases or changes during one-time braking, a stable friction coefficient is important.

In light of this history, we developed copper-free brake pads with the added value of a stable friction coefficient.

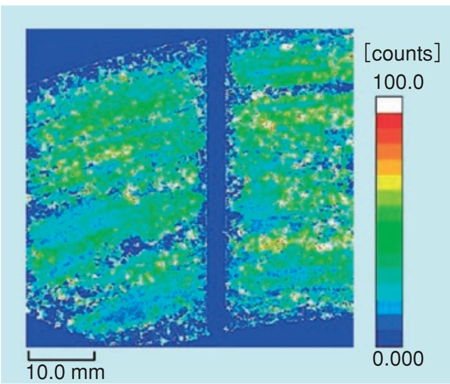


Figure 1 Copper layer on the brake pad formed after 500℃ braking (EDX)

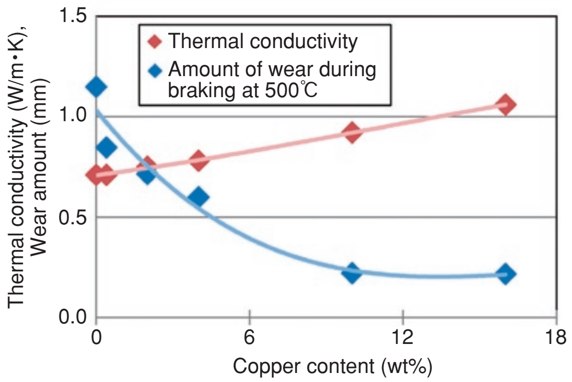


Figure 2 Lowering of thermal conductivity and wear resistance of brake pad by copper reduction

4 Technical Details

Product properties

As shown in **Table 1**, the developed product has a level of thermal conductivity and wear resistance similar to the current product containing copper. In addition, the change in the friction coefficient before and after a high-temperature braking history is less than that of the conventional product, and the rise in the friction coefficient after leaving a highly humid environment is low. As a result, the generation of squeaking or low frequency noises from the brake is low, meaning the pads are better than the current product.

Table 1 General properties of the new product

Item			Unit	Current product	Development target	Developed product
Copper content			wt%	15 <	0	0
Thermal conductivity			W/m・K	1.0	1.0	1.0
Stability of friction coefficient	Before high temperature braking	30 km/h 2.9 m/s²	—	0.40	0.40±0.04	0.38
		50 km/h 2.9 m/s²	—	0.42		0.38
		100 km/h 2.9 m/s²	—	0.46		0.40
		200 km/h 5.8 m/s²	—	0.31		0.38
	After high temperature braking	30 km/h 2.9 m/s²	—	0.45		0.40
		50 km/h 2.9 m/s²	—	0.48		0.42
		100 km/h 2.9 m/s²	—	0.46		0.44
		200 km/h 5.8 m/s²	—	0.30		0.36
	After leaving in high humidity*	5 km/h 1 MPa	—	0.58	≦ 0.50	0.49
Friction life**			—	○	○	○
Squeaking or low frequency noises of brake**			—	○	◎	◎

*At 30℃ for 6 h under an environment of 75% relative humidity **Outsourced evaluation of real automobiles

Achievement technique

For the purpose of improving thermal conductivity, we selected graphite with a high degree of graphitization and small grain size[5], and optimized the content to maintain the friction coefficient (**Figure 3**).

Furthermore, we selected the most suitable types of titanate in order to improve high temperature lubricity. The melting point and frictional property of the titanate vary depending on the components and crystal structure.[6] In this development, titanate with a melting point near that of copper and with a laminar crystal structure was selected to increase high temperature lubricity.

Because copper has a high intermetallic cohesive force against a disc rotor with cast iron as the partner material, the current product formed excessive metallic film after 500°C braking as shown in **Figure 1** and **Figure 4-A**. Generally, since intermetallic friction presents large fluctuations in the friction coefficient due to the disturbance from the change in the interface temperature,[7] excessive formation of copper and iron film impairs the stability of the friction coefficient. Graphite, selected as an alternative material for copper in this development, and titanate, with a laminar crystal structure that has low cohesiveness with iron, can restrict the excessive formation of metallic film (**Figure 4-B**). As a result, the friction coefficient of this developed product showed a stable friction coefficient against the disturbance from the braking conditions and history, thus achieving a reduction in squeaking or low frequency noises from the brake.

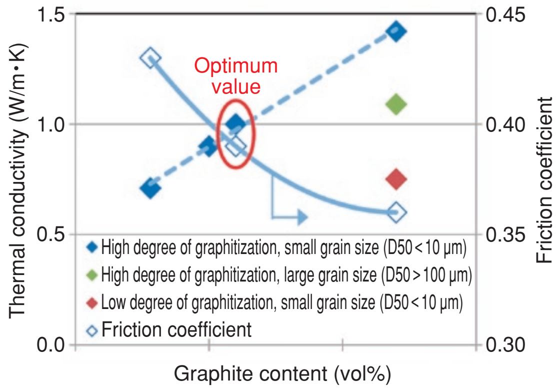
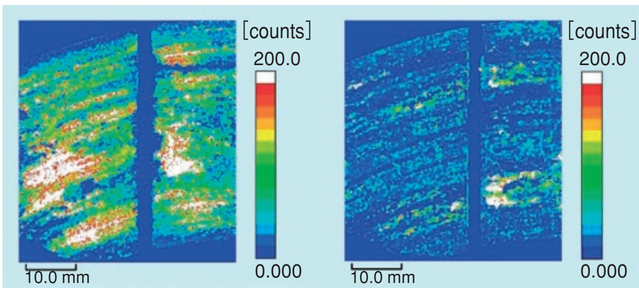


Figure 3 Optimization of degree of graphitization, size and contents of graphite



(A) Current product (B) Developed product

Figure 4 Iron distribution on the brake pad from disc rotor after 500 ℃ braking (EDX)

5 Future Business Development

・Start of mass production of developed product ・Expansion of application of copper-free brake pads to high load vehicles

【References】

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