Copper-Free Brake Pads with Stable Friction Coefficient

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1 Abstract

Brake pads of automobiles are required to have a stable coefficient of friction, which is correlated to squealing and vibration that impair the quietness of the vehicle. Because of the increase in regenerative coordinated brakes and improved automatic control technology accompanying the spread of electric vehicles, friction coefficient stability is strongly demanded. On the other hand, due to concerns that the copper contained in wear powder discharged from brake pads contaminates rivers, restrictions on the use of copper began in North America, and products sold in North America after 2025 will be made copper-free. This article describes the friction coefficient stabilization of copper-free brake pads that started production in 2016.

2 Characteristics of the Product

・Meets 2025 North American copper regulations.
・Excellent quietness (superior squeal and judder characteristics).
・Good friction coefficient stability and low wear during high-temperature braking.

3 Background of the Development

The brake pad is a part that stops the vehicle by frictional forces. A thermosetting resin (mainly phenolic resin), metal fibers such as iron and copper, inorganic fibers, organic fibers, and friction modifiers such as abrasives and lubricants are mixed to form a friction material that is bonded to an iron plate (**Figure 1**)[1]. Brake pads are required to have a high friction coefficient (μ), stability, wear resistance, and low abrasion of the brake disc. A stable friction coefficient (μ) leads to good braking performance and brake noise (**Figure 2**)[2]. High abrasion of the brake disc leads to uneven disc wear which causes judder[3]. Copper-free brake pads are being promoted in North America due to concerns about the contamination of river water by copper contained in brake dust[4]. Copper offers high thermal conductivity, melting point, and ductility. It exists at the friction interface to affect the friction coefficient stability and the wear[4].

Figure 1 Copper-Free Brake Pads

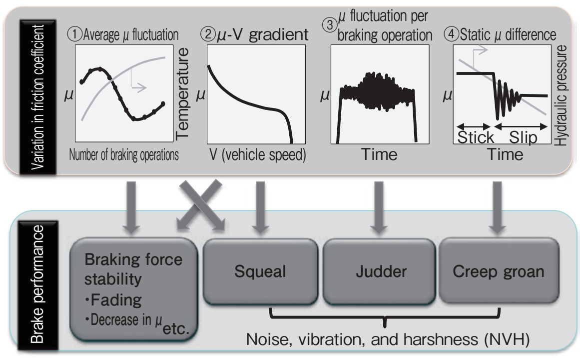

Figure 2 Relationship between Friction Variation and Brake Performance

4 Technical Details

Smeared copper can be seen on the friction surface of brake pads containing copper (**Figure 3**). Abrasiveness increased because the inorganic particles added to the friction material as an abrasive are retained in the copper film. With copper-free brake pads, the amount of disc wear is small even when the same amount of abrasive is added (**Figure 4**). Therefore, judder due to disc wear is unlikely to occur.

On the other hand, as the copper-free brake pad is in direct contact with the disc, changes in the organic matter contained in the brake pad are likely to appear as changes in the friction characteristics. The phenolic resin contained in the brake pad is thermally decomposed by friction so that thermal decomposition products are generated on the friction surface. Therefore, friction coefficient (μ) becomes unstable near the resin decomposition temperature, and the high-temperature wear tends to increase. Catalysts such as metals are known to decompose the thermal decomposition products and contribute to stabilizing the frictional properties[5]. In the copper-free brake pads we developed, potassium titanate was added that has a decomposition catalytic action on the decomposition products of phenolic resin[6].

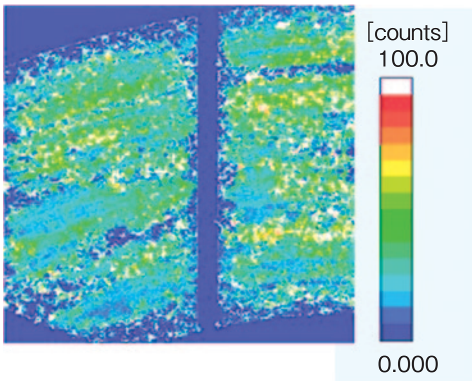

Figure 3 Copper on the Friction Surface of Copper- Containing Brake Pad

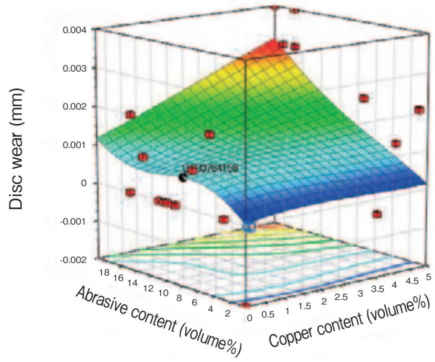

Figure 4 Effect of Copper on the Relationship between Abrasive Volume and Disc Wear

When friction tests are performed at different temperatures, the change in friction coefficient (μ) during braking increases near 400 °C even with copper-containing materials, and increased wear is apparent at higher temperatures (**Figures 5** and **6**). When titanate A is added, the increased change in friction coefficient (μ) and increased wear are observed at lower temperatures around 200 °C. However, when titanate B is added, the change in friction coefficient (μ) and increase in wear are only apparent at 500 °C.

The friction surface was observed when the change in friction coefficient (μ) was large. Unlike the friction surface when it was stable, the transfer film on the disk surface disappeared and the brake pad surface was pulverized into fine material. It is thought that the frictional interface fluidized due to the thermal decomposition products, making it easy for the friction material and the disc to come into direct contact and cause changes in the friction coefficient (μ) and increased wear.

The catalytic effect differed according to the type of titanate. In addition, the hardness and grain size also differed according to the type, and the average friction coefficient (μ) also differed. In the developed material, the mixing ratio was adjusted to meet the requirements for friction characteristics. This method also reduced brake noise.

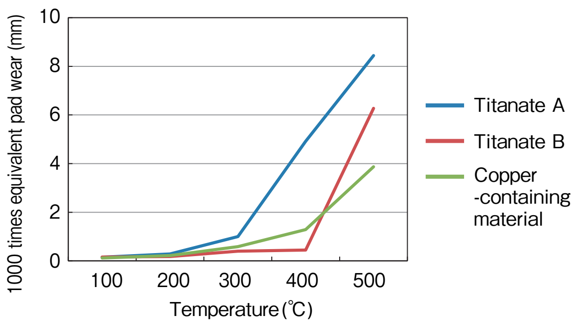

Figure 5 Temperature Dependence of Wear

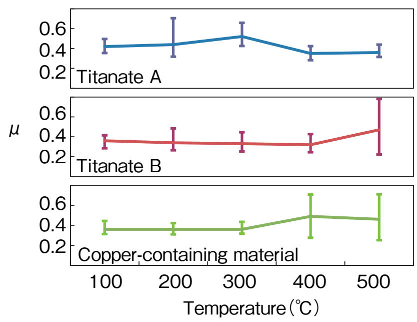

Figure 6 Friction Coefficient at Wear test
(The Bar Indicates the Friction Coefficient Variation during One Braking)

5 Future Business Development

・Application expansion of copper-free brake pads
・Measures to meet requirements for self-driving technology and regenerative braking

【References】

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