FRICTION COEFFICIENTS OF BORON MIXED BRAKE PADS

Muzathik AM[1,2], Mohd Nizam YB[1], Prawoto Y[3], Ahmad MF[1] and Wan Nik WB[1]

[1] Department of Maritime Technology, Universiti Malaysia Terengganu, Malaysia.
[2] Institute of Technology, University of Moratuwa, Moratuwa, Sri Lanka.
[3] Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, Malaysia.

Introduction

The friction material in an automotive brake system plays an important role for effective and safe brake performance. A single material has never been sufficient to solve performance related issues such as friction force and wear resistance [1]. Commercial brake friction materials contain mainly Alumina (Al_2O_3) and other ingredients. The ingredients contained binders, reinforcing fibers, solid lubricants, abrasives, fillers, additives and metal powders. The current research attempts to examine the mechanical properties of Boron mixed brake pads by comparing them with the commercial brake pads.

Methodology

Locally developed semi-metallic composite friction materials were studied for friction and wear. A semi-metallic commercial brake pad (ZMF) was used as a benchmark. Aluminum Oxide abrasive material which existed in ZMF formulation was taken out. It was replaced by consistently different weight percentage of Boron (0.6, 1.0, 1.5 and 2.0 %) and then mixed into the ZMF formulation. Material grouping were made based on these variations. The five groups were referred to as ZMF, ZMF+B0.6%, ZMF+B1.0 %, ZMF+B1.5 % and ZMF+B2.0 %.

Brake pad samples were repaired to the sizes of 26 mm x 26 mm x 7 mm. The weight and thickness of brake pad samples were taken before and after the friction test. In order to obtain average thickness value, three measurements were taken at different locations on the brake pad samples.

The friction tests were performed using the friction material test machine called CHASE machine with a pearlitic gray cast iron disc of 180 mm diameter and 38 mm thickness. The test samples were mounted on the load arm with 150 psi pressure and rotating disc moved with a constant sliding speed of 417 rpm.

Results and Discussion

Table 1 shows comparison test results of Boron mixed and commercial brake pads. The normal/hot friction coefficient test results were summarized from average four samples of Boron and commercial brake pad formulation individually. The results demonstrated that the formulations using Boron mixed brake pads produced higher normal and hot friction coefficient value than commercial brake pad.

Table 1: Summary of test results

Group of Brake Pad	Normal friction coefficient	Hot friction coefficient
ZMF Regular	0.43 FF	0.41
ZMF + B0.6 %	0.48 GG	0.50
ZMF + B1.0 %	0.51 GG	0.53
ZMF + B1.5 %	0.49 GG	0.50
ZMF + B2.0 %	0.50 GG	0.52

Figure 1 shows the sample run for first baseline condition. The temperatures range from 82^{o}C-101^{o}C during testing procedure. All friction coefficients of Boron samples increased at the beginning of braking stages until 20 braking applications. Among the Boron mixed brake pads sample ZMF+B2.0% showed the highest trend while ZMF+B0.6% was the lowest.

The friction coefficient of commercial (ZMF) sample became low at the fifth application and eventually constant after 20 applications. Heat generated during braking caused the surface temperature to increase with braking time which resulting the creating of tribo-films. For the commercial brake pad, tribo-films which were in the forms of Carbon started to created at the fifth application. The increase of tribo-films was accompanied by a decrease in friction coefficient at the fifth application onwards. The similar finding was reported by Shorowordi et al. [2].

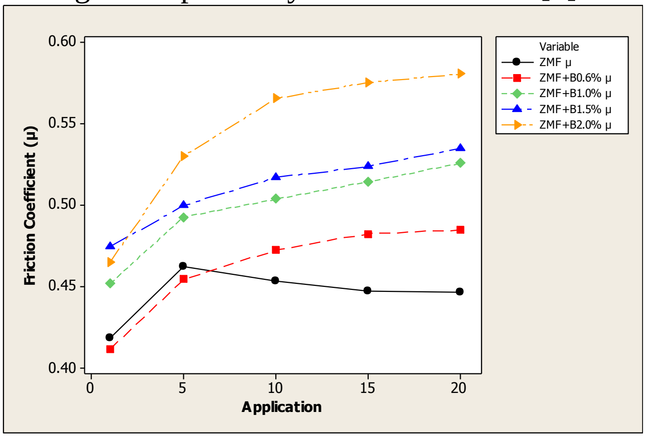

Figure 1 Friction coefficient for baseline condition

The Figure 2 shows the changes of friction coefficient as a function of disc temperature during the first fade condition for all samples. The load was applied continuously for 10 minutes or until the temperature reached 287ºC. The coefficient of friction was recorded with each increase in the temperature. Friction readings were taken at average of 23°C intervals.

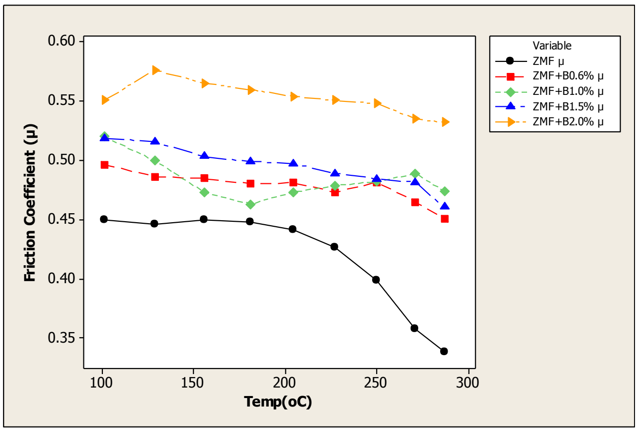

Figure 2 Friction coefficient vs disc temperature

When the friction coefficient decreases during braking due to the friction heat, the situation is referred to as fade and it is caused by thermal decomposition of ingredients in the brake lining. The study examined the changes of friction coefficient at temperatures of 101^{o}C to 287^{o}C. It appeared that an overall friction coefficient value declined with the increase in drum temperature.

However the reduction of friction coefficient for all Boron mixed brake pads was much more constant and stable as compared to the commercial brake pad. The reduction of friction coefficient of the commercial brake pads declined from 0.44 to 0.34, starting at a temperature of 204^{o}C to 287^{o}C. This situation was resulted from the softening of the Alumina fibers at the friction interface during sliding [3].

Meanwhile at the temperature of 204^{o}C, the average reductions of all Boron mixed brake pads were only minimal, reduced only by 0.02 (from 0.50 to 0.48). High thermal conductivity is believed to contribute to the stability of Boron mixed brake pads and fade resistance in high temperature.

Conclusion

The friction coefficient of Boron mixed brake pads and commercial brake pads were significantly different. The average friction coefficient of all Boron mixed brake pads was 0.495 (0.065 higher than the commercial brake pads). There was no significant difference in friction coefficient between all Boron formulations shown by CHASE test result.

The abrupt reduction of friction coefficient (fade) was more significant in the commercial brake pad samples than in Boron mixed brake pad formulations. Fade occurred in commercial brake pad sample at the lower temperature. All Boron formulations were more stable and constant than their commercial counterparts; the study reported only a slight reduction of friction coefficient.

References

1. Tang, F., Wu, X., Ge, S., Ye, J., Zhu, H., Hagiwara, M. and Schoenung, J.M. Dry sliding friction and wear properties of Boron Carbide particulate reinforced Al-5083 matrix composites. *Journal of Wear* 264 (2008) 555-561.
2. Shorowordi, K.M., Haseeb, A.S.M.A. and Celis, J.P. Tribo-surface characteristics of Aluminum-Boron Carbide and Aluminum-Silicone-Carbide composites worn under different contact pressures. *Journal of Wear* 261 (2006) 634-641.
3. Jang, H., Ko, K., Kim, S.J., Basch, R. and Fash, J.W. The effect of metal fibers on the friction performance of automotive brake friction materials. *Journal of Wear* 256 (2004) 406-414.