

Comparison of friction and wear performances of brake materials containing different amounts of ZrSiO_4 dry sliding against SiC_p reinforced Al matrix composites

Shaoyang Zhang*, Fuping Wang

Department of Applied Chemistry, Harbin Institute of Technology, No. 92, West Da-Zhi Street, Harbin 150001, PR China

Received 17 May 2006; received in revised form 10 August 2006; accepted 15 September 2006

Abstract

Low friction levels for brake materials dry sliding against Al matrix composites (Al-MMCs) were observed. Al matrix composites reinforced with 30 vol.% SiC_p (34 μm) were used first to fabricate a new brake drum in place of the conventional cast iron brake drum for a Chase Machine. Experimental studies on the brake materials differing in amounts of zirconium silicate (0 wt%, 4 wt%, 8 wt%, and 12 wt% ZrSiO_4) dry sliding against the Al-MMCs drum were performed on the Chase Machine in order to examine their effects on friction and wear performances. The test procedures include friction fade and recovery, load and speed sensitivities at 177 °C and 316 °C, and wear. Experimental results show that the brake material containing 8 wt% ZrSiO_4 had the best wear resistance and higher friction level. The brake material containing 12 wt% ZrSiO_4 had the highest friction level, but wear increased rapidly. The deterioration of the latter wear suggests that this brake material is unreliable in commercial applications.

© 2006 Elsevier B.V. All rights reserved.

Keywords: Zirconium silicate; Brake material; Al matrix composites; Friction; Wear

1. Introduction

Particle-reinforced Al matrix composites possess higher specific heat capacity and thermal conductivity, especially, lower density as compared with those of the conventional gray cast iron [1–4]. Considerable attention has recently been focused on Al-MMCs for manufacturing brake rotors and drums with the oil crisis and the increase of vehicle's fuel consumption. Parallel with all this work is the study on a new generation of brake materials. Many researchers have found that the friction coefficient of phenolic brake pads dry sliding against Al-MMCs is universally inferior to that of phenolic brake pads dry sliding against the gray cast iron and even falls below 0.30 [5,6], which gives rise to a loss of commercial value. Large amounts of transfer materials dominantly produced from brake pads are accommodated on the worn surface of Al-MMCs, forming thick tribofilms [7]. Minor values of the friction coefficient are mainly affected by the thick tribofilms since they reduce the shear strength between

the sliding surfaces. Seen from wear viewpoint, the formation of the thick tribofilms is helpful for protecting the brake pads from further abrasion. This work reveals that the friction coefficient completely contradicts wear. A simple method resolving the issue is to sacrifice wear to the friction coefficient because the latter plays a more important role during the actual automotive braking process. It has been reported that abrasive (ZrSiO_4) successfully removed the tribofilm, raising the friction level in brake pad–cast iron tribosystem [8]. However, the amount of abrasive is strictly restricted in commercial brake material applications because it does a lot of damage to the brake rotor and pad. Furthermore, small-size abrasive is easy to pull out from its matrix material and difficult to destroy the tribofilms, in particular, the thick ones. Therefore, an adequate size and amount of abrasive applied is possibly a key to remedying the low friction levels.

A substantial assessment of the material's frictional properties is a formidable task because some studies on phenolic brake pads dry sliding against Al-MMCs by different operators were performed using different experimental apparatuses and the size of samples under different operating conditions. The Chase Machine with a conventional cast iron brake drum, special

* Corresponding author. Tel.: +86 451 86419169; fax: +86 451 86413707.
E-mail address: zsy_1105@hit.edu.cn (S. Zhang).

equipment for brake pads and clutch facings of automobiles, has well been established as a means of determining friction levels. Testing sequences are intended to recreate actual operating conditions by implementing user defined loads, forces, temperatures, speeds and apply times. If the cast iron brake drum for the Chase Machine is replaced with an identical-size Al-MMCs drum, the same test methods used in brake pad–cast iron tribosystem can also be established for brake pad–Al-MMCs tribosystem so as to satisfy the requirements of practical applications. In this paper, we elaborate on the Al-MMCs drum and phenolic brake pad manufacturing processes, and the test procedure. Firstly, a brake drum available for the Chase Machine test was made of Al matrix composites reinforced with SiC_p. This was followed by the manufacture of disc brake pads containing different amounts of ZrSiO₄. They were then tested against the Al-MMCs drum on the Chase Machine according to the Society of Automotive Engineers (SAE) J661a criterion. Some other testing schedules were also implemented. Finally, friction models are put forward to help to analyze the results from these tests.

2. Experiment preparation and test method

2.1. Al-MMCs drum

Al-alloy had the following chemical composition except Al (in wt%): 11–13Si/0.8–1.5Ni/0.5–1.5Cu/0.8–1.3Mg/0.7Fe/0.2Ti/0.2Mn/0.2Zn. SiC_p used as reinforcements had 34 μm in nominal diameter. The Al-alloy was placed in a crucible and heated to 100 °C above its liquidus temperature, and the SiC_p to 500 °C to avoid the Al-alloy excess cooling when mixing. The melted Al-alloy and the preheated 30 vol.% SiC_p were mixed by means of agitation in the pressure/vacuum chamber. The mixed compositions were placed into the predetermined cast iron mould to fabricate a new brake drum for the Chase Machine through squeeze casting. The as-cast drum was then machined and checked for voids with an ultrasonic tester. No large-scale defects as cracks and porosity were detected. This was followed by a T6 heat treatment. The drum friction surface was polished with 1000 grit abrasive paper. The dust generated during polish was blown away by air jet from an air compressor. Subsequently the surface was cleaned out with acetone solvent and dried naturally. The surface roughness (R_a) was 0.61 μm measured with a surface profilometer. Its density and Brinell hardness were 2.84 g cm^{−3} and 158 HB, respectively. After the new drum in place of the original cast iron brake drum was

installed on the Chase Machine, a standard specimen of brake material was prerun against it at a speed of 6.1 m s^{−1}, load of 446 N and below 93 °C so as to reach a steady-state friction coefficient.

2.2. Test specimen

The compositions of the investigated brake materials and a portion of compositional hardnesses are listed in Table 1. Four formulations were determined by increasing ZrSiO₄ rate as 0 wt%, 4 wt%, 8 wt%, and 12 wt% and correspondingly reducing potassium titanate rate to have the total weight fixed at 100%. They were, in turn, named as Z0, Z4, Z8 and Z12. The choice of potassium titanate was fundamental in its good compatibility with binder resin and least effect in determining the friction coefficient than others [8–10]. The amount of phenolic resin was kept as small as possible to enhance high-temperature performance characteristics in finished products, especially, to impair friction fade. Glass fiber, aramid fiber and kyanite were blended first in a mixer for 3 min, where kyanite helped the fiber clumps open up. Then, the remainder was placed into the mixer to be blended for 6 min. The blended powder was weighed and then added into a mould. The brake material was moulded on a moderate-tonnage press at a pressure of 25 MPa and temperature of 165 °C for 10-min duration. The semi-manufactured goods were cured in a laboratory oven at 200 °C for 8 h. Specimens of 25.4 mm × 25.4 mm were cut from the finished products and ground to a thickness of approximately 6.0 mm before polishing by fine abrasive paper. Finally, the working face of each specimen could mate with the frictional surface of the Al-MMCs brake drum.

2.3. Chase Machine

A schematic of the Chase Machine (Jilin University, JF 160) is shown in Fig. 1. The drum diameter was 280 mm. When the cast iron drum for the Chase Machine was used, the adjustable speed, load and temperature ranges were 0–22 m s^{−1}, 0–2700 N and room temperature to 540 °C, respectively. In the present experiment, the maximum testing speed, load and temperature were restricted to 14.9 m s^{−1}, 1469 N and 343 °C, respectively, keeping in view the deformation tendency of Al-MMCs drum [11] due to its lower mechanical properties compared to those of the cast iron or steel [12]. An electric heater and an air blower were utilized to regulate the testing drum temperatures. The rubbing speed was controlled by a variable speed drive. The applied

Table 1
The compositions of the investigated brake materials and a portion of compositional hardnesses

Ingredients	Mohs hardness	wt%	Ingredients	Mohs hardness	wt%
Kyanite (<300 μm)	6	2	Glass fiber (4 mm)	5	36
Wollastonite (<200 μm)	5	3	Aramid fiber (2 mm)		2
Cashew (<0.5 mm)		2	Copper fiber (3 mm)	3.5	5
Molybdenum bisulfide (<10 μm)	2	2	Elastomer modified phenolic resin (<70 μm)		10
Magnesium oxide (<150 μm)	5.5	2	Zirconium silicate (40–60 μm)	7.5	0–12
Barium sulphate (<200 μm)	3.5	6	Potassium titanate (<12 μm)	4	Balance

Download English Version:

<https://daneshyari.com/en/article/1584585>

Download Persian Version:

<https://daneshyari.com/article/1584585>

[Daneshyari.com](https://daneshyari.com)