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Dry Sliding Tribological Characteristics of SiC Particle-reinforced Aluminum Composites in Brakes

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The dry sliding tribological characteristics were investigated using SiC particle-reinforced aluminum composites against semi-metallic frictional materials. The experimental results have indicated that, whether under the condition of continuous braking or not, the wear rates of SiC particle reinforced composites are much less than that of gray cast iron which is used as one of the common brake disk materials. At the same time, their frictional coefficients are about the same.
Key words: Dry sliding, composites, SiCp, tribological characteristics

1. Introduction

Composites of aluminum-base alloys possess superior properties. There have been many reports on the wear behavior of aluminum-matrix composites against steel or sand paper [1-4]. Several investigators pointed out that strengthening aluminum alloys with dispersion of fine ceramic particulates has dramatically increased their potentialities for wear resistant application. Axen et al.[5] reported that particle reinforced metal-matrix composites have better wear-resistant than fiber reinforced composites.

As development of automobile toward high speed, lightweight and low energy consumption, investigation on particle-reinforced aluminum matrix composites for brakes becomes even more urgent. Although several company have begun to use MMC aluminum alloy brake disks [6-7].

On the other hand, the fundamental tribological researches on aluminum composites are not enough to support the broad application of these materials to braking system; hence, the tribological behaviors of SiC particles reinforced aluminum composites were made in this paper. And as comparison, the tribological behaviors of gray iron (HT250 in Chinese Standard) were also made under the same testing conditions.

2. Experimental details

The composites for disk samples were fabricated using vacuum pressure infiltration process, which compositions are shown in table 1, the dimensions of disk are 140mm in diameter and 10mm in thickness. The gray iron disks were also cut from casting pieces in as-cast condition.

Table 1 The compositions of particle-reinforced aluminum composites

	Compositions of matrix alloys (%)				Reinforcement parameters		
Sample No	*Si*	*Mg*	*Mn*	*Al*	particle	Average size	Volume fraction
MMC1	10.0	0.3	0.4	balance	SiC	14.0 μm	20%
MMC2	10.0	0.3	0.4	balance	SiC	14.0 μm	30%

The block samples were directly machined from commercial "SANTANA" semi-metallic automobile front-wheel brake. The dimensions of the block sample are 13.4cm^2 in contacting area.

The dry sliding wear tests were performed on a self-made block-disk tester, which structure has mentioned in previous reports [8]. The tests were carried out at sliding velocities of 1.334$m.sec^{-1}$, 2.178$m.sec^{-1}$, 3.338$m.sec^{-1}$, 5.445$m.sec^{-1}$ and contacting pressure is 0.213MPa, 0.322MPa, 0.423MPa, and 0.555MPa.

The reiterative brake tests were carried out using a MM-1000 brake tester.

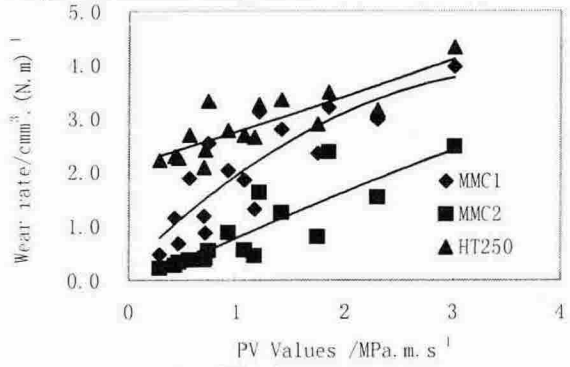
3. Experimental Results

3.1 Tribological characteristics under the condition of continuous braking

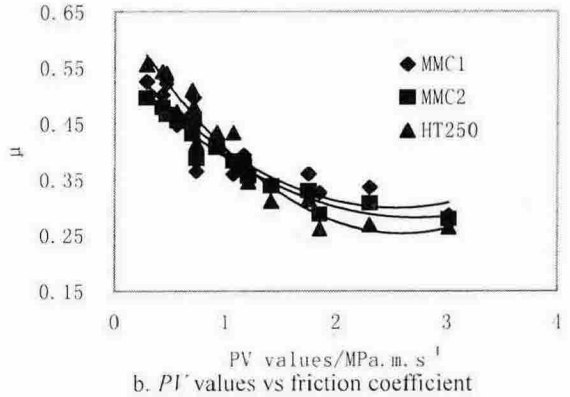
Figure 1 is the relationship between PV values and tribological characteristics under the condition of continuous braking. It is clearly seen that, with the increase in PV value, the wear rates of the materials increase, and frictional coefficients of the friction couples decrease. The average wear rate of three kinds of materials is HT250 ,2.82cmm^3.(N.m)$^{-1}$, MMC1, 2.10cmm^3.(N.m)$^{-1}$, MMC2, 0.90cmm^3.(N.m)$^{-1}$ respectively. For composite materials, with the increase in volume fraction of SiC particles, the wear-resistance increases. As for the frictional coefficients, there is no much difference among three kinds of materials. But under the condition of at lower PV values, the frictional coefficient of gray cast iron is higher than that of composites, while under the condition of higher PV values, the frictional coefficient of gray cast iron is lower than that of composites. This is because the thermal conductivity of iron is obviously lower than that of composites, at higher PV values, there are more friction heat to be transmitted into friction couple, the temperature of friction surface of iron is higher than that of composites, so the thermal decline of frictional coefficient of gray cast iron is more severe than that of composites.

Automobile brakes must have steady frictional coefficient. Stability of frictional coefficient can be described by fluctuant range of frictional coefficient. Fluctuant range of frictional coefficient is defined as the differential of maximum and

minimum frictional coefficients determined by tests. The experimental results indicate that, with the increase in sliding speed, the fluctuant ranges of frictional coefficients decrease, and the fluctuant range of frictional coefficient of gray cast iron is larger than that of composites.



(a). *PI'* values vs wear rate



b. *PI'* values vs friction coefficient

Fig.1 Relationship between *PI'* values with tribological characteristics under the condition of continuous brake

3.2 Tribological characteristics under the condition of reiterative brake

Figure 2 presents the average wear rate and friction coefficients from MM-1000 brake tester. The trends are compatible with that on self-made block-disk tester. During reiterative brake testing. The average wear rate of composites are lower than that of gray cast iron and the average friction coefficients correspond to that of gray cast iron.

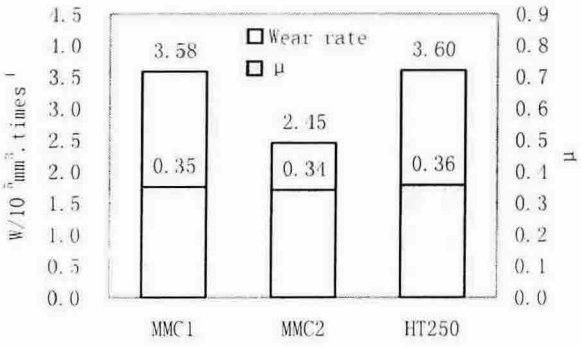


Fig.2 The average friction coefficient and wear rate tested on MM-1000 brake tester

From the braking moment of testing materials, it is clearly seen that composites possesses more stabile braking property. These results have further indicated that composites are superior to gray cast iron in brake stability.

4. Conclusions

(1)Although they have about the same friction coefficients, the wear rates of SiC particle reinforced composites are much less than that of gray cast iron whether under the conditions of simulating continuous or reiterative braking. And considering the mass of SiC particle reinforced composites to be only one third that of gray cast iron, SiC particle reinforced aluminum composites have wider application foreground for making vehicle-braking components.

(2)With the increase in *PI'* values, the wear rates of materials increase , and frictional coefficients of friction couples decrease. Thermal decline of frictional coefficient of gray cast iron is higher than that of SiC particle reinforced aluminum composites.

(3)With the increase in SiC particles volume fraction in particle reinforced aluminum composites, the wear-resistance of composites increase, and average frictional coefficient appreciably decrease.

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