Inertia Dynamic Friction Properties of Pitch-based Carbon-Carbon Composites

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Introduction

Carbon-Carbon (C/C) composites have been considering the best choice as an advanced aircraft brake disk materials on account of their low density, excellent thermo-mechanical and high wear resistance due to self-lubricating capability[1-2].

In this experiment, three different kinds of C/C composites having different friction surfaces such as continuous 8-harness satin fabric, chopped fiber (V_f=45%) and chopped fiber with higher volume fraction (V_f=55%) were prepared. Inertia dynamic friction tests were carried out in terms of initial braking speed, braking pressure and number of braking stops.

Experimental

The C/C composites used in this study were prepared by the pitch impregnation and carbonization process. Table 1 shows the specimen designations, density, heat treatment temperature and friction surface conditions for the three kinds of C/C composites. The tests were performed using a small-scale inertia dynamo-friction tester in air to evaluate the effect of the initial rotating speed on the friction and wear properties.

Results and Discussion

Friction coefficient: Typical friction torque vs. elapsed time under the initial rotating velocity of 5500 rpm and 8.0 kg/cm^2 of breaking pressure for the C/C composites are shown in Fig. 1. All of the samples showed similar friction torque curves having higher friction coefficient at the initial and latter braking stage than the middle stage. Friction coefficient variations at various initial velocities at a braking pressure of 8.0 kg/cm^2 are shown in Fig. 2. As shown in the figure, all specimens exhibiting high friction coefficients at 4500 rpm decreased slightly with increasing initial velocity and dropped considerably at 5500 rpm. This might be explained by the friction surface change from particulate wear debris to film-like debris owing to the increase of the velocity. Fig. 3 shows the variation of a friction coefficient as a function of braking pressure. Considerable variation of the friction coefficients were observed with the increase of a braking up to 7.0 kg/cm^2, but friction coefficients showed a tendency to decrease at 8.0 kg/cm^2. These friction coefficient behaviors are coincident in some degree with the previous results insisting on the lower friction coefficient in the higher PV value in C/C composites.

Wear behavior: Wear rates by the thickness difference under the test conditions of 5500 rpm and 8.0 kg/cm2 are shown in Fig. 4. While the wear rates of sample 1 and sample 2 at initial braking stops decreased at less than about 50 stops, the ware rate of sample 3 showed a slight increase. From these wear behaviors of an initial stage, about less than 50 stops, sample 1 and sample 2 seem to develop wear films on the friction surfaces much easier than sample 3 owing to low hardness as shown in Table 2.

Conclusions

Continuous fabric friction surface showed about 2 times higher friction coefficient than those of the chopped fiber composites. All specimens exhibited a decrease of friction coefficients with increasing the initial velocity and braking pressure. The wear rate tending to decrease about within the 50th stop increased with further increase in the number of stops.

References

1. Awasthi S, Wood J.L. C/C composite materials for aircraft brakes. Phil. Trans. R. Soc. London, 1980; A294, 583-590
2. Ju C.P., Chen J.D., Lin J.H.C.. Effect of load on tribological behavior of C/C composites. J. Mater. Sci. 1996;31: 1221-1229.

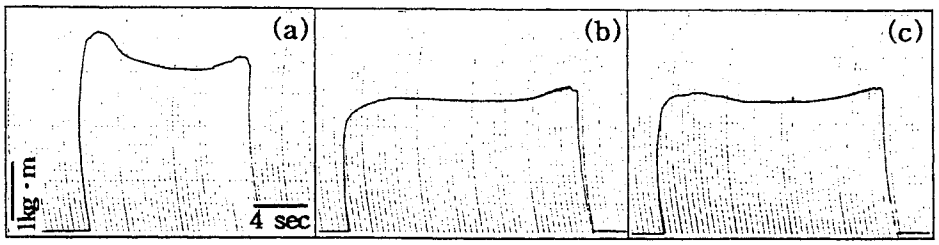

Figure 1. Friction curves of the three kinds of C/C composites (a) Sample 1 (b) Sample 2 (C) Sample 3 (X-axis: Elapsed time, Y-axis: Torque)

Table 1. Three Different C/C Composites Tested in This Study.

	Sample 1	Sample 2	Sample 3
Density (g/cm3)	1.77	1.78	1.79
Matrix Precursor	Coal-tar Pitch	Coal-tar Pitch	Coal-tar Pitch
Friction Surface	Continuous Fabric (8HS)	Chopped fiber (0.5-2 mm)	Chopped fiber (0.5-2 mm)
Impregnation & Carbonization	0.001 psi / 735 psi	0.001 psi / 735 psi	0.001 psi / 735 psi
Heat Treatment (°C)	2100	2100	2100

Table 2. Rockwell Hardness of the Three Different C/C Composites.

	Hardness (HR15-T)
Sample 1	47.4
Sample 2	60.3
Sample 3	72.3

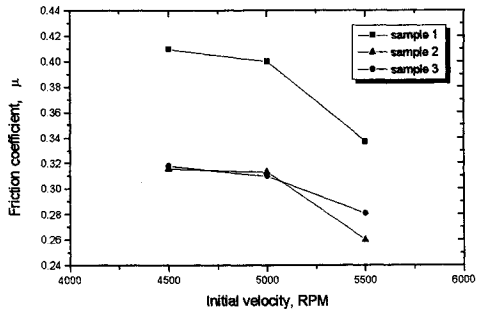

Figure 2. Change of friction coefficient under the various initial velocities and braking pressure of 8kg/cm^2

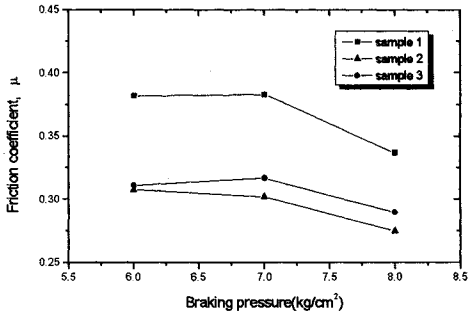

Figure 3. Change of friction coefficient under the various braking pressures at initial velocity of 5500 rpm

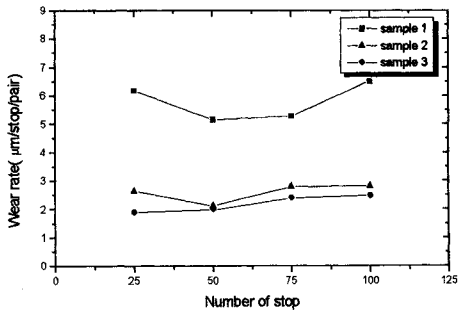

Figure 4. Variation of wear rate by thickness change for the three different C/C composites after every 25 stops under 5500 rpm and 8kg/cm^2