FRICTION PERFORMANCE OF A SERIES OF PITCH MATRIX C-C COMPOSITES.

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INTRODUCTION.

Currently, the largest market for C-C composites is in their utilization as the heat sink and friction material for aircraft brakes. Aircraft brakes function by converting the kinetic energy of a moving aircraft to heat through friction and therefore, the energy of a brake stop is determined by the speed and weight of the aircraft. As a result of the wide variation in speed and weight of an aircraft during a given flight, aircraft brakes are required to perform under a wide range of energy conditions.

Traditionally, two types of C-C composite have been utilized as friction materials for aircraft brakes. The first type of C-C composite consists of a laminate of fabric or felt which is densified with carbon by Chemical Vapor Infiltration (CVI) of a hydrocarbon gas such as methane. The second type of C-C composite is comprised of a randomly oriented chopped fiber architecture with a hybrid of resin and CVI carbon matrices.

A third type of composite comprised of carbon fiber reinforcement with a pitch matrix has been investigated in these studies. Pitch matrix composites offer potential advantages over resin and CVI matrix composites including higher thermal conductivity and density. This paper describes the effects of kinetic energy and contamination on the friction performance of C-C composites fabricated using pitch matrices.

EXPERIMENTAL

The investigations were conducted on four experimental C-C composite materials that were comprised of carbon fibers and a pitch matrix. All of the composites were manufactured at the Niigrafit Institute, Moscow and differed with respect to their filler type, structure and process conditions. The four materials were designated TD, STD, DNV and DF. The TD and STD materials were comprised of continuous Rayon fibers and a pitch matrix and differed only with respect to their final heat treatment temperature. The TD composites were heat treated to 2000^{o}C while the STD materials were heat treated to 1500^{o}C. The DNV composites were comprised of continuous PAN fibers in a pitch matrix and also heat treated to 2000 C. The DF composites were similar to the DNV materials but contained discontinuous short chopped filaments.

The processes used to fabricate the composites was similar and involved impregnation of the fibrous preforms with molten pitch. The composites were then carbonized to transform the isotropic pitch to an anisotropic coke. Densification of the resulting preforms was performed using conventional pitch processing technologies which involved multiple cycles of pitch impregnation-carbonization heat treatments. These heat-treatments were conducted under high pressures (15,000 PSI) to improve the coke yield [1]. It should be noted that regardless of the fiber type and the process conditions used, the density of all four composites was quite similar 1.65 - 1.75 g/cm^3.

The friction performance of the pitch matrix composites was investigated using a subscale dynamometer. The dynamometer test conditions were varied with respect to initial velocity, disk interface pressure, and the inertia moment of the fly-wheel mass in order to simulate different kinetic energy conditions experienced by aircraft brakes. The wear test geometry was disk on disk. Therefore, the test samples were machined into rings of dimension 75mm OD, 53mm ID and 14mm thickness. Using this procedure the dependence of friction coefficient on a specific kinetic energy was determined for all four C-C composite materials.

In order to determine the effect of contaminants on the friction performance of C-C composites samples of the DF composite were prepared in the following conditions: dry, soaked in non-phosphate containing detergents and soaked in phosphate containing detergents. Following soaking with the various contaminant solutions the discs were dried at different temperatures from room temperature up to 800°C prior to performing the dynamometer tests.

RESULTS AND DISCUSSION.

Figure 1 shows the friction coefficient values of the four C-C composites (TD, STD, DNV and DF) as a function of kinetic energy. The results indicate that there is a general trend of decreasing friction coefficient with increased kinetic energy for all materials except the DF material. The friction values of the TD, STD and DNV materials decreased from approximately 0.35 for a landing condition (2200 J/cm^2) to approximately 0.25 for a RTO condition (8500 J/cm^2). This is typical for C-C composites and is unfavorable since it is at the higher energies that higher friction values are desirable.

However, the friction coefficient of the DF material was stable in the kinetic energy range from 2200 to 8500 J/cm^2. The DF material differed from the other materials in that it contained discontinuous chopped fibers. and exhibited the highest density 1.75 g/cm^3.

The results of the contamination investigations are given in Figure 2 which shows the effect of contaminants on the friction coefficient of the DF C-C composite as a function of the disk temperature. The results show that the pre-dried non-contaminated C-C composite exhibited low friction coefficient values (0.25) at temperatures less than 100°C. There was a rapid increase in friction coefficient for disks that were pre-dried at temperatures between 100 and 200°C which corresponds to the removal of moisture from the C-C composite material. At temperatures greater than 200°C the friction value gradually decreased to 0.35 at a temperature of 800°C.

The samples of DF composite that were soaked in non-phosphate containing detergents exhibited extremely low friction values (less than 0.1) at low temperatures (24°C - 200°C). The friction values gradually increased with increased temperature and at 500°C approached the friction values of the dry C-C composites. This effect is very similar to that of disks soaked with water. The samples of DF composite that were contaminated with phosphate containing detergents also exhibited low friction values (0.05) at temperatures less than 200°C. However, unlike the non-phosphate contaminated disks the phosphate contaminated disks showed only limited recovery of the friction values at high temperatures. The friction coefficient of the phosphate contaminated DF material remained less than 0.1 at temperatures approaching 600°C.

Further studies in this area are now being investigated.

CONCLUSIONS

1). The friction performance of a series of pitch matrix C-C composites showed a high degree of variation as a function of kinetic energy. Such differences in friction performance are related to differences in their structure and composition.

2). Generally, the friction values of the pitch matrix composites decreased with increased kinetic energy.

3). Different contaminants effect the friction coefficient of carbons to different degrees. Phosphate containing detergents cause an unrecoverable loss of friction.

REFERENCES

1. L. E. McAllister and W. L. Lachman, in: A. Kelly and S. T. Mileiko (Eds.), "Multidirectional C-C Composites"; Handbook of Composites, (1983) 109.

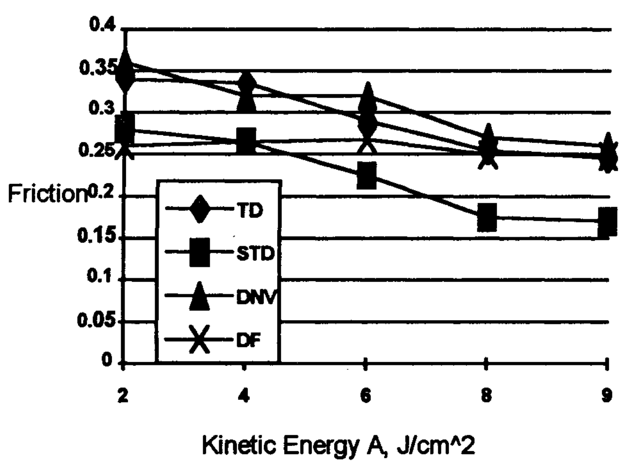

Figure 1. The Effect of Kinetic Energy on Friction.

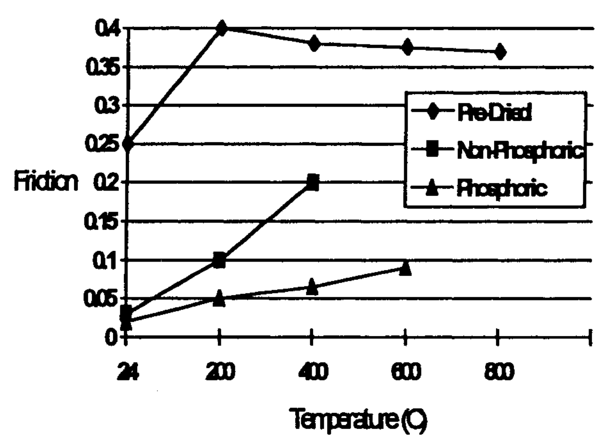

Figure 2. The Effect of Contamination on Friction