STUDIES ON FRICTION PROPERTY OF C/C COMPOSITES UNDER LOW ENERGY LOAD

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Introduction

C/C composites have been widely used as braking material and C/C composite braking discs have been equipped with many military and commercial aircraft in some advanced countries for years. The research and manufacture on C/C composite braking discs in China was just started at the middle of 1980's. According to the landing and initial braking factors of the aircraft, we studied the tribological property of C/C composites many times but fail of studying on relevant tribological properties under operating factors of low energy and low speed, such as taxing, this is not good for the aircraft designer and customers to have a fully understanding of the aircraft properties. Therefore, we here list a number of parameters, with it, we have satisfactorily done a series of experiments under low energy and low speed.

Sample Preparation And Experiment

The experiment is done with a C/C composite consisting of C-fibers reinforcing a C-matrix, the C-fibers are PAN-based C-fibers and be weaved as the substrate of composites, the carbon matrix is a CVD carbon from the pyrolyzing of acryl or propane. Differential pressure CVD process is operated in a vacuum induction furnace. The inner portion of the fiber preform in the furnace is sealed off from the furnace chamber at the base(1). Hydrocarbon gases are fed into the inner cavity at a negative pressure with respect to the furnace chamber. A pressure difference that forces the hydrocarbon to flow through the pores depositing carbon and exiting as hydrogen is created across the formation of an outer crust on the surface of the preform and facilitates densification uniformity. The properties of the C/C composite are summarized in table-1 as follows.

Testing equipment; B1000 model inertial dynamometer.
Sample friction surface size: Φ272×Φ184mm,
Sample quantity: 2 rotors, 3 stators.
Testing combination: ① friction surface pressure is 0.60MPa , initial braking speeds are 3.2m/s, 6.4m/s, 9.6m/s, 12.9m/s and 19.2m/s respectively; ② Friction surface pressure is 0.87MPa, initial braking speeds are 3.2m/s. 6.4m/s; 9.6m/s 12.9m/s19.2m/s and 29.8m/s respectively; ③ Friction surface pressure is 1.19MPa, initial braking speeds are the same as ②. The moment of inertia for the above is fixed at 14500kg.m^2.

Discussion

After the test data are arranged, a relational curve by friction coefficient vs. friction speed is got.

After studied the interrelationships of friction coefficient vs. friction speed and surface pressure, it's appreciated that friction coefficients are risen up followed that of friction speed from 3.2m/s to 12m/s and descend when it's over 15m/s. The max. coefficients in 12-15m/s range are existed and its values are over 0.4.

Friction coefficients are sensitive to friction surface pressure. It is a general trend that friction coefficient are slightly descend when surface pressure is upward. But the friction coefficients are not very sensitive to pressure when friction speeds are higher.

Friction coefficient can be characterized by the following equation(2):

$$f = \frac{\sigma_0}{P_c} + d_g K \sqrt{\frac{h}{R}} \qquad (1)$$

Where σ_0 is the shearing strength of molecular bonded force between friction interfaces, Pc is the actual pressure of operating point, d_g is delay lost factor, K is the factor based on geometric contacting shape, h is the depth sunken antithesis by unit roughness and R is the round radius of unit roughness.

In the equation (1), the 1st item expresses the effect of material property on friction coefficient, the 2nd item expresses the effect of friction surface condition on friction coefficient. In present investigation, friction surface condition takes a primary part in tribological property when braking speed is lower, that is to say h/R takes a primary part in this item. Material's property comes to a key factor along with the increasing of braking speed, and a film is thus formed on friction surfaces. The film is uninterruptedly formed and uninterruptedly broken in friction movement when it is about 13m/s and makes the highest coefficient and max. wearness. Braking speed gradually increased as that of kinetic energy at the same time, so that friction surface temperature is risen and film is softened thereby gradually, friction coefficients are reduced, and tends to a stable level.

According to equation (1), P_c increases and f reduces when the pressure is risen up.

Friction speed of C/C composite friction surface within 12m/s to 15m/s means a smaller braking energy, at this time peak values f appeared in the above experiments are named low energy peak values. This property of C/C composite braking material is important to braking system design and its operation. Grasping the property is helpful to lift the controllability, stability and safety of the braking system.

Conclusions

(1) Friction coefficients of c/c composite braking material are possessed of low energy peak value in inertial dynamometer test , testing peak values of two pair of braking discs appeared in the initial braking speed range of 12m/s to15m/s.

(2) If pressure is increased on friction surface, friction coefficients of multi-discs brake slightly reduced.

References

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Table.1 Nature for C/C composite

Bulk density (g/cm^3)	Fiber Volume Fraction (%)	Tensile Strength (MPa)	Tensile Modulus (GPa)	Thermal Conductivity (W/m.K)
1.72-1.84	25-38	84-112	22-35	9-33

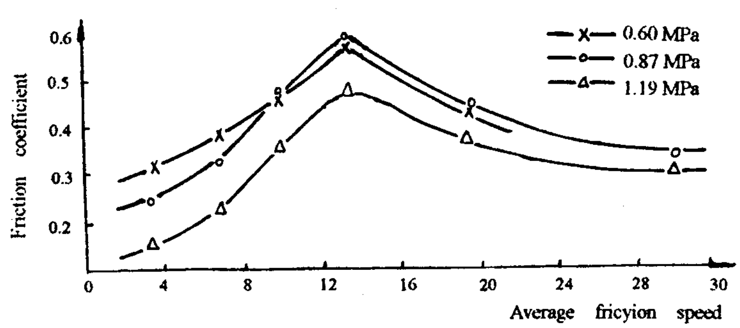

Fig.1 Variation of friction coefficient of C/C composite discs with friction speed