Dynamic Torque Characteristics of high Performance Carbon/Carbon Brake Disk for an Advanced Aircraft

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INTRODUCTION

Because of their low density, excellent high temperature mechanical property, self-lubricating and high heat absorption capabilities, carbon/carbon composites have been considered one of the best materials in the aircraft industry. Although aircraft brake is a core part of the landing system being consumed very much and connected directly with the safety of a pilot only several countries have succeed in developing carbon/carbon brake disk in the worldwide. In partnership with the Daewoo Heavy Industries Ltd. We, the Agency for Defense Development have been developing carbon/carbon brake disk. In the brake disk development it is required and necessary to test and evaluate dynamic torque property of the brake materials using an inertia dynamometer. In accordance with the specifications of MIL-W-5013 and the GD16ZL001B of the General Dynamics (Lockheed) regarding the development of aircraft brake disk we have performed dynamic torque test consisting of 45 stops of landplane landing design gross weight, 5 stops of maximum landing design gross weight and 1 stop of maximum design gross weight(rejected take-off) for several sets of the prototype brake assembly. In addition to the test, a service life test of 500 stops has been performed under the purpose of evaluating service life and reliability of brake performance. All results from these tests have satisfied the requirements.

EXPERIMENTAL

In order to develop high performance brake disk being used for an advanced aircraft brake carbon/carbon brake disks having not only a enough density but also good thermal and mechanical properties have been prepared for performing a dynamic torque test being used as a method of qualification test for an aircraft brake through the fabrication and assembly processes such as preparation of green composites, densification process including several times of liquid impregnation with pitch/ carbonization, high temperature heat-treatment at 2200℃ ,chemical vapor infiltration(CVI), non-destructive test (NDT), metal channel installation and antioxidation treatment at non-friction parts. Table 1 shows the representative properties of carbon/carbon brake disk.

Several times of dynamic torque test consisting of 45 stops of landplane landing design gross weight, 5 stops in maximum landing design gross weight and 1 stop of maximum design gross weight braking (rejected take-off) were performed in accordance with the MIL-W-5013 using a certified inertia dynamometer which can simulate the aircraft kinetic energy absorbed by a brake disk assembly in an aircraft landing and the results were evaluated by criteria such as a maximum braking pressure, braking stability, braking distance, tire bead and wheel temperature. Table 2 is the conditions of dynamic torque test. In addition to the dynamic torque test, a service life test of 500 stops required for evaluation of brake service life and braking performance reliability has been performed in accordance with GD16ZL001B. Figure 1 shows the photograph of the rejected take-off test and Figure 2 shows the prototype brake disk assembly.

RESULTS AND DISCUSSION

From the qualification tests, the prototype brake assembly has shown a superior braking capability such as braking performance, braking stability, wear property and heat energy absorption capability comparing with an existing qualified carbon/carbon brake disk and has satisfied the all requirements. During the service life test the prototype brake disk assembly has shown no failure and reliable braking performance. From the service life test the carbon/carbon brake disk was projected having more than 1000 landing cycles. Table 3 shows the results of 45 stops in landplane landing design gross weight. Figure 3 represents the wear curve of a brake disk assembly by the thickness change during the service life test.

REFERENCES

1. MIL-W-5013, "General Specification for Aircraft Wheel and Brake Assemblies," 1982.
2. General Dynamics Specification 16ZL001B, "Wheel and Brake Assembly : Aircraft Main Landing Gear 25.5 x 8-14 Tubeless."
3. ARP 1493, "Wheel & Brake Design and Test Requirements for Military Aircraft," 1979.

Table 1. Typical properties of the carbon/carbon brake disk

Density (g/cc)	Tensile strength (MPa)	Compressive strength (MPa)	Flexural strength (MPa)	ILSS (MPa)	Thermal conductivity (W/m.K)
>1.75	80-100	110-140	100-140	10-12	25-30(∥) 80-90(⊥)

Table 2. Conditions of dynamic torque test

Test conditions	A	B	C
Aircraft weight(lbs)	19,500	27,500	37,500
Inertia equivalent weight of dynamometer, max.(lbs)	9,536	12,650	13,191
Braking kinetic energy(ft.lbs x 10^6)	5.7	10.5	18.1
Braking velocity(knots, min.)	116	137	176
Tire load(lbs)	7,380	10,147	13,811
Tire rolling radius(inches)	11.7	11.4	11.3

A: Landplane landing design gross weight braking test
B: Maximum landing gross weight braking test
C: Maximum design gross weight braking test(Rejected take-off test)

Table 3. Test results of 45 stops in landplane landing design gross weight

Items	Requirements	Existing brake	Prototype results
Braking pressure(psi)	2,300	959	506
Braking torque(in.lbs)	NA	29,494	33,286
Deceleration rate ($ft.sec^2$) min.	8.60	8.47	9.17
Braking distance,max.	2,238	2,251	2,136
Braking temperature(℃)	NA	500-700	600-700

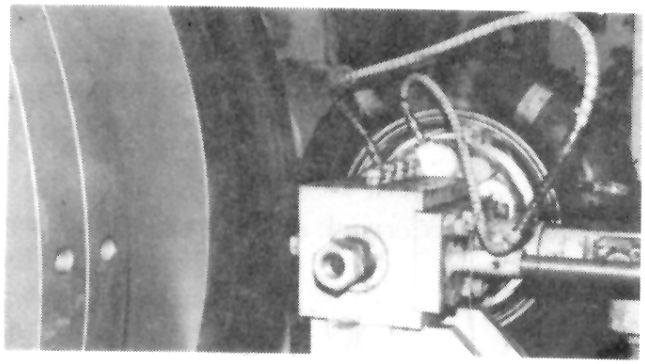

Figure 1. Photograph showing RTO test

Figure 2. Photograph showing brake disk assembly

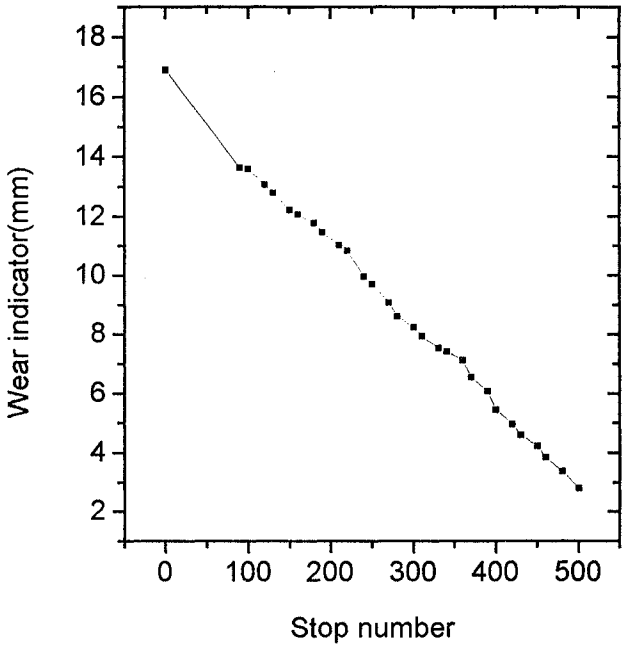

Figure 3. Change of wear indicator during 500 service life tests