TECHNICAL NOTE

PROCESSING AND FRICTION PROPERTIES EVALUATION OF MULTILAYER CU MATRIX HYBRID COMPOSITE BRAKE PADS FOR A TRAINER AIRCRAFT

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Abstract

We have developed three types of multi layer Cu matrix composite brake pads, namely, Copper-silica-BN, Copper-Si_3N_4-graphite, and Copper-mullite-MoS_2 to solve the problem of static torque, friction coefficient in the upgraded version of Trainer aircraft. These composite brake pads were tested in a full scale brake dynamometer and static torque testing unit at ARDC, HAL. Our results shows that the braking requirements of static torque (~ 204 Kgfm), friction coefficient (~0.3-0.45) were very well met in the multilayer Copper-mullite-MoS_2 composite brake pads. The role of MoS_2 and Mullite in improving static torque, friction coefficient and stabilizing frictional properties in this composite brake pads were explained in detail.

Introduction

The comprehensive reviews of processing and testing of the high energy powder metallurgy (P/M) composite brake pads are given in Ref. [1-3]. This article reports the solution to the problem faced in the upgraded version trainer aircraft P/M composite brakes in our division. Multilayer Cu/ Silica/ Graphite composite brake pads developed by HAL (F&F) and certified by CEMILAC have been proved to be a promising candidate for brake pad applications in the Trainer aircrafts of following braking design (older version) characteristics, as given in Table-1.

However, the above composite brake pad did not provide satisfactory frictional properties such as static torque and friction coefficient for upgraded version of trainer aircraft. During our trial experiments, the static torque and friction coefficient values achieved were 40-50% lower than the requirements. The design parameters of upgraded version of trainer version are also given in Table-1.

Experimental Procedure

The brake pads were processed through powder metallurgy technique. The processing sequence involves special mixing technique of preparing metallic and reinforcement mix separately and then blending all mixes together in the ball mill. The composite brake pad mix was compacted in a steel cup under uniaxial pressure of 250 MPa at room temperature. The green compacts were sintered by pressure less sintering technique at 900°C under reducing atmosphere in a pusher furnace. The sintered compacts are repressed to improve its dimensional stability, densification and minimize the residual stresses in the brakepad. The typical process flow chart and testing procedures of brake pad are given in Ref.[1-3].

Results and Discussion

Frictional tests on multilayer Cu/Silica/Graphite composite brake pads showed that reinforcement and lubricant in the copper matrix fail to stabilize the friction at higher temperature dissipation (650-700°C) arising from increased braking energy. The amount and type of reinforcement (silica) was insufficient to deliver increased static torque requirement.

To solve this challenge, we have processed three types of multi layer Cu matrix brake pads, namely, Copper-silica-BN, Copper-Si_3N_4-graphite, and Copper-mullite-MoS_2. Those composite brake pads were tested for braking parameters of upgraded version of trainer aircraft

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Table-1 : Braking Design Parameters for both Older and Upgraded Version

Design Parameters	Older Version	Upgraded Version
Aircraft maximum all up weight	4890 Kg	5400 Kg
Brake energy	5.9 MJ	6.3 MJ
Static torque	194 Kgfm	230 Kgfm
Dynamic coefficient of friction	0.3 - 0.45	0.3 - 0.45

in full scale brake dynamometer and static torque testing unit at ARDC, HAL.

Experimental findings suggested that the multilayer Cu/Mullite/MoS_2 composite brake pad is able to meet the requirements of upgraded version. The details of test results are confidential in nature. We bring out here scientific understanding of the test results.

Role of Mullite

The higher volume fraction (~38%) was found necessary to generate sufficient friction and retain thermal stability at higher dissipation temperature. Due to which, the spacing between particles gets reduced which makes more number of particles to be in contact with counterface and generate high static friction. Further, Mullite has better fracture toughness than silica and this minimizes the particle fracture assisted wear at elevated temperature Ref. [4].

Role of Molybdenum Disulphide

The presence of adsorbed vapors such as moisture or volatile organic solvents on graphite is essential to retain its lubricating properties. At higher braking energy, the increased friction temperature desorbs all adsorbed vapors and causes the graphite to loss its lubricity. Therefore, the mechanical mixed tribolayer (MMTL) at the interface was not formed by the graphite to stabilize friction coefficient and wear. As an alternative lubricant, we have chosen MoS_2 as one of lubricants in our studies. The MoS_2 lubricant does not require condensable vapors to retain its lubricating properties because hexagonal crystal structure with six fold symmetry makes these properties intrinsic to MoS_2, as reported in Ref. [5]. The analysis of wear surface morphology showed the evidence of MMTL in the MoS_2 reinforced Cu-Mullite composite brake pad, which stabilized the necessary friction and wear properties at much higher interface temperature due to increased braking energy.

Conclusion

We have processed three types of multi layer Cu matrix composite brake pads, namely, Copper-silica-BN, Copper-Si_3N_4-graphite, and Copper-mullite-MoS_2 using powder metallurgy. These composite brake pads were evaluated for braking conditions of transport aircraft upgraded version (6.3 MJ).

- Multilayer Cu/Mullite/MoS_2 composite brake pads meet the braking requirements of upgraded version transport aircraft.
- Mullite and MoS_2 are the best reinforcement and lubricant to provide high static friction with controlled wear loss.
- The high volume fraction of 38% Mullite is necessary to generate consistent friction with minimal wear loss.
- The non-dependence of lubricating properties of MoS_2 with condensed vapors makes it to a stable lubricant at high braking energy conditions.

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